NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

COMPANY TEAM SURVIVABILITY
AT THE U.S. ARMY
NATIONAL TRAINING CENTER

by

Steven A. Stoddard

June 1998

Thesis Advisor: Harold J. Larson
Second Reader: Samuel H. Parry

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COMPANY TEAM SURVIVABILITY AT THE U.S. ARMY NATIONAL TRAINING CENTER

Steven A. Stoddard
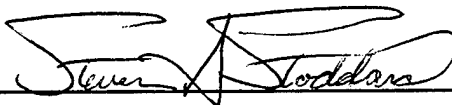Captain, United States Army
B.S., United States Military Academy, 1988

Submitted in partial fulfillment of the
requirements for the degree of

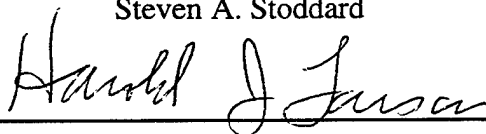## MASTER OF SCIENCE IN OPERATIONS RESEARCH

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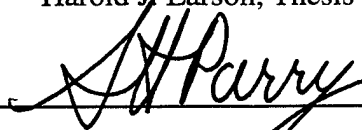
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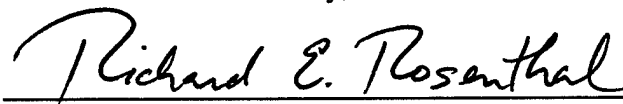**June 1998**

Author: _____

Steven A. Stoddard

Approved by: _____

Harold J. Larson, Thesis Advisor

_____

Samuel H. Parry, Second Reader

_____

Richard E. Rosenthal, Chairman
Department of Operations Research

ABSTRACT

This research answers the following questions about training exercises at the Army's National Training Center (NTC) at Fort Irwin, California: "Which company team was the most survivable in the task force," and "What did that company team do differently to become the most survivable?" The research examines data collected over four month-long brigade training exercises at the NTC, including analysis of 88 company team battles. The measure of effectiveness (MOE) is the average system survival time for each company team for each battle. The company team that achieves the highest MOE score for a battle is considered the most survivable company team. The MOE is scaled for comparisons over the course of many battles. The MOE is then used as the dependent variable for a series of separate analyses of the data, which answer the second question. These analyses use a collection of 20 independent variables and six research questions to differentiate between more and less survivable company teams. The conclusions are that company teams whose leadership survives longer, who have a higher proportion of tanks, and who perform security operations better are more survivable. The research further recommends that the NTC's data collection efforts be automated and standardized among the collection teams.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This research answers the questions about training exercises at the Army's National Training Center (NTC) at Fort Irwin, California: "Which company team was the most survivable in the task force," and "What did that company team do differently to become the most survivable?" For each task force battle, the relative survivability of each company team is compared to the other company teams within the task force. It also examines each company team's performance in a variety of tasks from the planning, preparation, and execution phases of the operation.

The research examines data collected over four month-long brigade training exercises at the NTC, including analysis of 88 company team battles. All of the selected battles were of the force-on-force variety and used the Multiple Integrated Laser Engagement System (MILES) – no live fire battles were considered.

To answer the first question (above), the measure of effectiveness (MOE) is the average system survival time for each company team for a given battle. The company team that achieves the highest MOE score for that battle is considered the most survivable company team. The MOE is scaled for comparisons over the course of many battles. The MOE is then used as the dependent variable for a series of separate analyses of the data, which answer the second question. These analyses use a collection of 20 independent variables over the three phases of an operation and six research questions to differentiate between more and less survivable company teams.

The conclusions are that company teams whose leadership survives longer, who have a higher proportion of tanks, and who perform security operations better are more survivable. The research also shows significant relationships between survivability and performance of combat service support operations, boresight operations, actions on contact, the effect of enemy engagement areas, and the proportion of losses from indirect fire. The research further recommends that the NTC's data collection efforts be automated to allow for analysis of lethality. The NTC must also standardize the collection of subjective data to ensure that all collection teams gather data on the same items and use the same evaluation scale. This will enable the NTC to maintain data "on-the-shelf" for future research.

I. INTRODUCTION

A. GENERAL

The National Training Center (NTC) at Fort Irwin, California, performs one of the most important training missions in the United States Army – that of preparing battalion task forces and brigade staffs for combat. The objectives of training at the NTC are to increase unit readiness, train leaders, embed doctrine throughout the Army, provide feedback to the Army, and provide a data source for lessons learned [Ref. 1]. The NTC provides a unique opportunity to assess training proficiency and provide feedback to the training units. Its large maneuver training areas and world class opposing force (OPFOR) allow for full-scale battalion and brigade force-on-force operations. During the past 16 years, the Army has added a computer-driven, live-fire complex with sophisticated targetry and a state-of-the-art instrumentation system.

Each year, twelve brigades from around the Continental United States (CONUS) go to the NTC for 24-day rotations during which they are thoroughly trained and assessed. Each of these brigades (called the BLUEFOR) brings 3500 to 5000 soldiers, including its infantry, armor, artillery, air defense, and aviation assets, as well as its staffs and its combat support and combat service support units. These units provide communications, engineers, intelligence, maintenance, chemical protection, etc. The brigades treat their rotations and conduct their missions as if they are in a combat zone from start to finish. They treat their arrival at Fort Irwin as if they were entering a hostile area of operations. Their first battle is a movement to contact (MTC) to locate the enemy and develop the conflict. From there they fight a series of offensive and defensive operations against the OPFOR, culminating in four days of live fire operations against computer-driven plywood targets. Following the battles, they repair and return the equipment they used during the rotation for the next unit to arrive, which replaces them in the combat zone.

B. PROBLEM DESCRIPTION

The Army's principal doctrinal manual, FM 100-5 *Operations*, states that "commanders seek to apply overwhelming combat power to achieve victory at minimal cost." To do so, they must combine "the elements of maneuver, firepower, protection and

leadership" [Ref. 2]. This research focuses on one aspect of force protection – company team survivability – and how the other elements of combat power impact on survivability. The questions that this research attempts to answer is, "Which company team was the most survivable within its task force?" and, "What did that company team do to become the most survivable?"

Currently, those questions are not directly answered and the NTC makes no apologies for that. The Observer Controllers' (O/Cs) principal mission is to train and provide feedback to the training units. They do not keep score of wins and losses. In fact, they do not even declare winners or losers after battles. Instead, the O/Cs focus on evaluating the tasks the units perform during the battle (i.e., performance of reconnaissance, use of indirect fire, preparation of a battle position, etc.). The O/Cs also provide training on how to improve task performance through a series of after action reviews (AARs). A brigade can expect to receive 600 AARs at all levels during their rotation. Each task force also receives a Take Home Package (THP), which is a consolidation of all battles and lessons learned for the task force from the entire rotation.

The questions of which company team is the most survivable in the task force, and what makes that company team the most survivable, then remain.

C. SCOPE OF THESIS

This will answer the first question (above) by identifying a Measure of Effectiveness (MOE) that quantifies the relative success (in terms of survivability) of the company teams in relation to each other. With that complete, the most survivable company team (or teams) from the task force will be easily identifiable following any battle. The tool to identify that company team must be easily used by the Tactical Analysis Facility (TAF) analysts who track the battles for the O/C teams and it must not place additional workload burden on those analysts. Any additional workload might cause their other analysis tasks to suffer.

The answer to the second question will come in the form of models of the data observed. Using the objective data from the TAF analysts and the subjective data from the O/Cs, the models will show trends that allow predictions of which company team will be the most survivable in a task force battle. Given that, those trends could be disseminated

2

to the force to allow units to improve their training by focusing on those areas that are most likely to lead to better survivability.

D. THESIS STRUCTURE

The next chapter of this thesis gives a brief overview of NTC operations and explains how data are gathered. Chapter III details the selection of the MOE that will answer the question, "Which company team was the most survivable in the task force?" It will also show a detailed description of a battle from the NTC, and how the MOE is used to answer the question for that battle. Chapter IV explains the development and selection of models that answer the question, "What did that company team do to become the most survivable?" as well as the research questions stated in Chapter II. It examines all the available indicators and then reduces the model to provide a usable, accurate predictor to identify trends that lead to success in terms of survivability.

II. BACKGROUND

A. NTC OPERATIONS

To accomplish its critical mission of preparing battalion task forces and brigade staffs for combat, the National Training Center (NTC) is organized into three primary components: the training unit (BLUEFOR), the opposing force (OPFOR), and Operations Group.

Each month, a new BLUEFOR unit arrives at the NTC from somewhere in the Continental United States (CONUS). A brigade-sized unit comes with all the assets it would take to war. Typically, that includes two or three maneuver task forces, an artillery battalion, a forward support battalion, an engineer battalion, an air defense battery, a chemical platoon, a military police platoon, a signal platoon, and a military intelligence platoon. Often, the brigade also brings up to a battalion of aviation assets that vary from attack and observation helicopters to utility helicopters that will provide lift for infantry, reconnaissance, or materiel assets. Usually, the brigade receives some close air support from the Air Force as well. Each maneuver task force is made up of three to five infantry and/or armor companies and a headquarters company. The infantry companies are typically equipped with 14 M2 Bradley Infantry Fighting Vehicles (IFVs) and the armor companies will typically have 14 M1A1 Abrams Main Battle Tanks. Often, these companies will task organize for particular missions by "trading" or "loaning" platoons to provide a mix of armor and infantry where needed.

The BLUEFOR will train at the NTC for a 24-day period. During the first five days, they will train as if they are first entering a combat zone. They will use this time to draw their equipment just as if they were drawing it from one of the many staging areas around the globe. They will also conduct their preliminary reconnaissance of the area of operations (AO). On the sixth day, the BLUEFOR will depart the "drawyard" and enter the AO. Their first mission will be a movement to contact (MTC) so that they can gain contact with the OPFOR and develop the conflict. Over the next eight days, the BLUEFOR will conduct a series of offensive and defensive operations against the OPFOR throughout the expansive training area on the Fort Irwin reservation. Following the force-on-force portion of the training, the BLUEFOR will fight a four day series of live-fire

battles against computer activated plywood targets. This adds to the realism of the training as units fire live ammunition to include small arms, tank rounds, anti-tank missiles, mortars, artillery, rockets, demolitions, etc., during both day and night operations. Following the live-fire operations, the unit departs the AO and spends four to six days cleaning and repairing the equipment for the next unit that will come to the NTC to train.

The OPFOR, also known as the 11th Armored Cavalry Regiment, is a permanent force at the NTC. The Regiment provides the OPFOR for every unit that comes to the NTC to train. Consequently, they are extremely proficient at the business of land combat and they know the terrain of the NTC very well. The mission of the OPFOR is to provide a tough, realistic enemy for the training unit. The OPFOR is equipped with both authentic and modified vehicles that replicate the tanks, personnel carriers, and reconnaissance vehicles that are most common in potentially adversarial countries. They fight using the tactics of those countries as well.

Operations Group conducts a myriad of tasks to ensure that the training is as realistic and demanding as possible, and that the BLUEFOR departs the NTC as well trained as possible. Operations Group provides the higher headquarters for the BLUEFOR brigades so they can give them realistic missions and train the brigades' staffs. It also provides each training unit from brigade level down to platoon level, as well as all staff sections, with Observer/Controllers (O/C) and conducts the After Action Reviews (AAR). Among other duties, Operations Group handles the complex instrumentation system of the NTC that allows for realistic training and effective data gathering, replicates the media on the battlefield, and controls the battle by "refereeing" to ensure realistic training.

B. DATA GATHERING

The most significant contributor to the realism of the force-on-force portion of the training is the Multiple Integrated Laser Engagement System (MILES) and the Simulated Area Weapons Effects (SAWE) system that supports it. Simply put, MILES is a laser tag system. Each weapon in the BLUEFOR and OPFOR is equipped with a MILES transmitter. When a soldier pulls a trigger, the weapon gives off a signature similar to the firing of a real round of ammunition; however, a laser beam is emitted instead of a bullet or missile. Each soldier and vehicle in the training area is fitted with a laser receiver to

allow the soldier or vehicle to be "hit" by the laser beam. Each MILES transmitter is coded by the type of ammunition it is replicating, as is each MILES receiver, to further ensure realistic training. Thus, when an M1 tank from the BLUEFOR shoots at an enemy T-80 tank from the OPFOR, the MILES system will determine if the round missed the target, nearly missed the target, or hit the target; and, if it hit the target, it will assess the appropriate amount of damage. The tank crew that was hit will receive a variety of indicators to alert them to the situation. Their radio will not work, except to tell them the extent of the damage. Also a yellow "whoopee" light will flash, so that anyone who could see the damaged vehicle will know that it was hit. The SAWE portion of the system replicates the impact of artillery and mines in much the way MILES does for direct fire engagements.

Virtually every event that occurs in the NTC's training area is observed from the TAF and recorded in the NTC's database. The events include any vehicle movement, any movement by a team of dismounted soldiers, any firing of weapons from the MILES system, any target effects from direct fire, indirect fire, mines, etc. All of the data are available for AARs and for trend analysis.

The same events that go into the database go directly to each task force TAF. The TAFs get a digital, live, overhead view of each battle as it progresses. It sees where every element is all the time, the status of those elements (alive, dead, degraded), and can observe all direct and indirect fire engagements. The TAF uses this information to assist the O/Cs in AAR preparation and in preparing the unit's Take Home Package (THP).

Also, the TAF collects a variety of subjective observations from the O/Cs to assist in the analysis and contribute to the AARs and THPs. These observations provide insight about each company team's performance during the planning, preparation, and execution portions of each battle. The specifics of these observations will be discussed later in detail.

C. RESEARCH QUESTIONS

The feedback from the O/Cs to the training units occurs primarily during the AARs. The focus of each AAR is on the critical tasks conducted during the operation in support of the unit's mission and the commander's intent for the operation. They do not typically address survivability as a separate issue. As mentioned earlier, survivability is

synonymous with protection, which is one of the four elements of combat power (along with maneuver, firepower, and leadership). The Army Research Institute conducts frequent studies to analyze various devices that are designed to increase survivability of both individual systems as well as units. This research will examine actions during the course of an operation that reflect on company team survivability.

Knowing the answers to those questions would allow for two significant events. First, the O/Cs could use that information immediately following a battle to improve the feedback in the AARs. Units who suffer many losses can see what other, more survivable, units have done differently and they can make adjustments starting with the very next mission. Second, the Army could disseminate to the force the common traits of the company teams that have proven to be the most survivable in their task forces. Once identified, those traits could be trained at home stations for the general improvement of units throughout the Army.

This research will attempt to answer several questions concerning company team survivability in order to determine what makes some company teams more survivable than others, and more importantly, what can company teams do to become more survivable? These questions are as follows:

1. In each of the three phases of an operation – planning, preparation, and execution – what tasks, when performed to standard, are most indicative of a company team that is more survivable that others?

2. In which of the three phases is successful task performance most indicative of a more survivable company team?

3. All things taken equally, which potential indicators offer the best predictions of how survivable company teams will be?

4. Which indicators, when examined individually, differ significantly between more and less survivable company teams?

5. Does task organization affect company team survivability?

6. Does the type of mission cause different indicators to become more indicative of the level of company team survivability?

D. PREVIOUS THESES AT THE NTC

This is the fourth thesis from the Naval Postgraduate School written for the NTC in support of its mission to train battalion task forces and brigade staffs. The first three provided tools to improve the quality of data and data encapsulation for future analysis. They gave tools to the O/Cs that, once implemented, would enable them to give improved feedback to the training units. This thesis is intended to put some of that previous work into use and bring the analysis work back to the training units.

CPT Kirk Benson's thesis [Ref. 3] modeled the data encapsulation and communications network for the NTC to allow the NTC to manipulate its technology to accomplish certain goals. CPT Dana Goulette's thesis [Ref. 4] provided a means for standardized measurement of the subjective data from the battles. CPT Stanley Olenginski and CPT Alan Seise's joint thesis [Ref. 5] provided a standardized, multimedia CD-ROM take home package for TAF analysts to compile and issue to training units as they depart the NTC to return to their home station. Those theses have accomplished their purposes by providing effective tools to the NTC. This thesis will put those tools into use.

III. SELECTION OF MEASURE OF EFFECTIVENESS

To answer the question, "Which company team was the most survivable in the task force?" we need an appropriate measure of effectiveness (MOE). The principle issues when answering such a question are:

Which systems survived the battle?

How long did the systems that were lost in the battle survive?

If we know how long a unit kept its systems alive during the battle, we can assess its relative survivability. The company teams that keep their systems in the fight longer typically bring their task force the most maneuver and firepower assets through the course of the battle. In short, if we can answer those two questions, we can determine the most survivable company team in the task force.

This research only considers tanks and infantry fighting vehicles (IFVs) as the systems. Armor and mechanized company teams also typically have an indirect fire support vehicle (FIST-V), a field ambulance, a heavy recovery vehicle, a maintenance vehicle, and, frequently, air defense and engineer assets. Although these systems are important to a company team's survivability, the reasons for their survival are more open to speculation and circumstance. For example, the fire support team that is attached to the company might have responsibility for observing certain indirect fire targets. If the company team reacts to a contingency away from the targets, the fire support team might separate and act independently for a time or attach itself to another unit. Similar circumstances govern the proximity of the other assets to the company team.

A more significant system that has been left out is the dismounted infantry. Dismounted infantry operate quite differently from their mounted counterparts. Frequently, they become casualties while still mounted in their Bradleys. They are often assigned missions separate from their company's mission. An analysis that includes dismounted infantry is certainly relevant, but beyond the scope of this research. Also, any analysis of dismounted infantry survival would be better suited for the Joint Readiness Training Center (JRTC) at Ft. Polk, Louisiana. (The JRTC is the dismounted equivalent of the NTC.)

To capture this information (as well as information concerning volume of fire), the O/Cs use Battle Damage Assessment (BDA) cards. On the BDA cards the company team O/Cs record the following for each weapon system: the type of weapon system, the bumper number, the MILES "kill code" which reveals what type of enemy caused the damage, and the time the weapon system was lost. Table 1 shows an example of a BDA card recorded for a battle that occurred in December 1997.

Type	BMPR#	Kill Code	Time	120mm	25mm	TOW
M1	A66	7	10:00	5		
M1	A65	7	11:15	3		
M1	A11			16		
M1	A12			23		
M1	A13	UMCP				
M1	A14			22		
M1	A21	UMCP				
M1	A22	10	11:22	16		
M1	A23	10	11:25	10		
M1	A24	10	11:20	14		
M2	C11	UMCP				
M2	C12	10	9:45			
M2	C13	FASCAM	11:30		450	1
M2	C14	FASCAM	11:35		507	3

Table 1. Battle Damage Assessment Card for Alpha Team, TF 1-9 Cav (Mech)

Notes: M2 = Bradley Infantry Fighting Vehicle
M1 = Abrams Main Battle Tank
A11 = Alpha Company, 1st Platoon, 1st Tank
Kill Code 7 = enemy infantry fighting vehicle
Kill Code 10 = enemy tank
Other Kill Codes include FASCAM (a type of mine field), ARTY (artillery), UMCP (for vehicles that did not participate in the battle because they were at the unit maintenance collection point), and many others
120mm = number of tank rounds fired by that system (e.g., A11 fire 16 tank rounds in this battle)
25mm = number of Bradley chain-gun rounds fired by that system (these are used against lightly armored systems)
TOW = number of anti-tank missiles fired from the Bradley

Figure 1. Explanation of terms on Battle Damage Assessment cards.

Using the information from the BDA card, we can first assess a survivability score for Alpha Team by summing the system-minutes that they provided to the task force during the battle. The reasoning behind this is simple. The longer that systems survive in the battle, the more survivable the company team is; and, therefore, the longer that system can contribute to its company team's mission.

A system that enters the battle is given credit beginning from the time a task force becomes engaged with the enemy (not including task force reconnaissance and security forces) until the system is lost as a combat asset. This loss could be the result of direct fire, indirect fire, maintenance, or a minefield. A system that survives the entire battle is given credit until Change of Mission (COM) time. Change of Mission time is when the O/Cs determine that the battle has reached its conclusion and the fighting should stop so the units can focus on reconstitution of losses and on conducting their AARs.

For example, the above unit (from Table 1 and more detailed information in Appendix B) became engaged and suffered its first loss at 0930 hours and later received change of mission at 1145 hours. 2nd Tank Platoon, Alpha Team is scored as follows:

A21:   no credit
A22:   1122 – 0930 = 112 minutes
A23:   1125 – 0930 = 115 minutes
A24:   1120 – 0930 = 110 minutes
Total: 337 minutes

By adding the survival minutes for the remainder of Alpha Team (see Appendix A) we see that the team total would be 1137 system-minutes (it receives no credit for the systems that were at the UMCP during the battle).

The next step in MOE establishment is to account for different task organizations of company teams. For instance, companies teams can operate purely as armor or as mechanized infantry; or, they can provide a mixture of the two systems. Also, company teams are subject to attachment and detachment of platoons that might give them the advantage of many more systems or the disadvantage of operating with relatively few systems. To account for this, the MOE will scale the total system-minutes by dividing by the number of systems in the company team. Thus, the MOE will be the average number

of minutes survived for each system that was in the company team at the start of the battle. For the above example, Alpha Team's average survival minutes is 1137 system-minutes / 11 systems = 103.4 minutes. Task organization will be addressed again in the discussion of indicators in Chapter IV.

Further scaling is required to account for the "pace" of the battle. Some battles take a lot less time than others. Some battles have proportionately higher casualties than other battles. Without further scaling, a company team that has all fourteen systems survive a one hour battle may appear to be less survivable than a unit that suffers many losses over the course of a ten hour battle. Since the MOE must reflect which company team is the most survivable in its task force during a given battle, regardless of the pace or lethality, the company team with the highest average survival minutes per system within its task force will receive an MOE score of 1.00 for that battle. The other company teams will receive an adjusted MOE score to be scaled off that most survivable company team. For example, suppose the company teams in the task force had the following averages for surviving system-minutes:

Alpha Tank:	103.4 minutes
Bravo Tank:	71.5 minutes
Bravo Mech:	114.7 minutes
Charlie Mech:	43.3 minutes

Since Bravo Mech was the most survivable company team in the task force for this battle, the MOE scores are as follows:

Alpha Tank:	0.90
Bravo Tank:	0.62
Bravo Mech:	1.00
Charlie Mech:	0.37

Thus, we can easily compute which company team in a task force is the most survivable using the O/C's Battle Damage Assessment cards. The computed scores can then be analyzed to determine if certain aspects of that company team's performance are indicative of how survivable the company team will be.

For the TAF analysts to use their BDA cards to answer the question of which company team was the most survivable, they can use the Survivability Spreadsheet. At the completion of a battle, each of the company team TAF analysts simply inputs the relevant information for his company team. At the bottom of the page, the Survivability Spreadsheet shows which company team had the highest average system survivability for that battle. Appendix B shows a blank Survivability Spreadsheet and one from a battle from the December 1997 rotation at the NTC.

IV. DATA ANALYSIS / REGRESSION MODEL

A. POTENTIAL INDICATORS

The indicators that will likely show why some company teams are more survivable than others can be broken down into categories representing the planning, preparation, and execution phases of the operations, as well as some indicators that are common throughout the phases. Care was given in selection of the indicators to ensure that gathering data for this research did not make any negative impact on the O/Cs or the training units. The indicators discussed in this chapter are routinely evaluated at the NTC by all company team O/Cs.

During the planning phase, the O/Cs evaluate how well a company team does in execution of the Warning Order (WARNORD), dissemination of the operational graphics, preparation and issuance of the Operations Order (OPORD), timeline utilization, direct fire planning, and risk assessment. All of these areas except timeline utilization are subjectively evaluated by the O/Cs on a "to standard" / "not to standard" basis. All of the O/Cs are subject matter experts in company team operations and have company command experience. The twelve company team primary O/Cs are supervised by three task force O/Cs who are former battalion commanders. The company team O/Cs compare notes and strive for standardization among themselves on each task. For the subjectively evaluated indicators, this simple scale is probably as acceptable a measure of performance on the tasks as is available anywhere.

The WARNORD is a brief order that alerts the unit that an operation is upcoming. It gives the unit some direction and priorities of work in preparation for the mission while the commander makes his tentative plan, conducts reconnaissance, and completes the OPORD. It has no required format, but typically includes the following [Ref. 6]:

1. Nature (attack, defend, movement to contact, etc.) and time of mission.
2. Earliest time of next movement.
3. Tasks to be accomplished prior to the issue of the OPORD.
4. Time, place, and attendees for the OPORD.

The operational graphics include the maneuver graphics, fire support graphics, intelligence graphics, and combat service support graphics. They come in the form of transparent overlays that, when affixed to a map of the area of operations, represent all relevant operational locations with the appropriate symbols. These symbols include check points and phase lines that help units coordinate their movements, direct fire and indirect fire target reference points, templated and actual locations of enemy units, locations of obstacles, ambulance exchange points, chemical decontamination sites, and many other items. Each of these are issued to the company team commander when he receives the task force operations order. The company team must effectively combine and disseminate the graphics so that each system can operate independently and properly communicate during the operation.

The OPORD is a much more structured document than the WARNORD. At the company team level at the NTC, commanders typically spend 45 to 60 minutes just to issue their orders to their subordinate leaders. The OPORD has five paragraphs, each with specific requirements [Ref. 6]:

1. Situation
2. Mission
3. Execution
4. Service Support
5. Command and Signal

The preparation and issuance of OPORDS is taught to commanders repeatedly during pre-commissioning education, at officer basic courses, and, most thoroughly, at officer advanced courses, which commanders generally attend one to three years prior to their command tour.

The direct fire plan is part of the Execution paragraph of the OPORD. The O/Cs evaluate this task separately from the OPORD itself (to be discussed further in the Data Collection section). It focuses on how the company team will use its direct fire assets (tanks, TOWs, Bradley chain guns, and machine guns) to kill the enemy and destroy his equipment. It includes how the commander plans to distribute fires, at what ranges he wants to use which systems, what types of enemy systems he prioritizes as targets for each

of his systems, and how he plans to control direct fire using fire control measures such as engagement areas, target reference points, and sectors of fire [Ref. 6].

Risk assessment refers to how the company team examines the risks that they are taking in the operation and what they are doing to minimize those risks. "Field Marshal Erwin Rommel defined risk as a chance you take; if it fails, you can recover. A gamble is a chance taken; if it fails, recovery is impossible" [Ref. 2]. Specifically, the O/Cs evaluate how well company teams identify, assess, and implement controls for hazards such as potential fratricide situations, security issues, etc. They also examine how well company teams account for the effects of weather, sleep deprivation, training and experience on task performance.

Timeline utilization refers to what portion of the available planning and preparation time the company team commander took in preparation and issuance of the OPORD. As he works through the Troop Leading Procedures, he strives to prepare the best possible plan for how his company team will fight while still allowing his subordinates to have enough time after he issues the plan for them to prepare for the battle. These data are recorded in two ways. First, they are recorded as a percentage of the available time the company team commanders use from when they receive their task force OPORDs until the battles begin. The standard is 33 percent – known as the "one-third / two-third rule". Commanders attempt to issue their OPORDs close to 33 percent of the way through their available timeline. Doing so should give commanders enough time to prepare effective orders while maximizing the time for their company teams to execute the tasks that occur in the preparation phase of operations. The timeline utilization can also be described by a Boolean variable with a "1" corresponding to a company team whose proportion of time used was less than or equal to 33 percent and a "0" otherwise.

During the preparation phase, the O/Cs examine how well company teams execute local security operations, combat service support operations, rehearsals, boresighting, pre-combat inspections, and maintenance. All of these except maintenance are evaluated on the same subjective scale ("to standard" or "not to standard") as in the planning phase.

Security is a principle of war, defined as not permitting "the enemy to acquire unexpected advantage" and it "results from measures taken by a commander to protect his

19

forces" [Ref. 2]. O/Cs evaluate how well company teams conduct local security by observing their security posture (e.g., one man manning a machine gun from every tank and IFV), their conduct of security patrols, their emplacement and conduct of observation posts, their use of chemical defense alarms, etc. Sometimes units lose systems prior to the beginning of a battle because of poor security operations. We could reasonably expect a unit that does a better job of conducting security operations to be more survivable than a unit that does a poor job.

Combat service support operations are those that provide the means for a company team to sustain its combat operations throughout a campaign. They give "the assistance provided to sustain combat forces, primarily in the fields of administration and logistics" [Ref. 7]. Specifically, the O/Cs evaluate how well companies conduct supply, maintenance and medical operations. Supply operations include daily resupply of food and water, mail, necessary petroleum products to include fuel, acquisition of supplies to include spare parts, batteries for night vision devices, and replacement of broken tools. Maintenance operations focus on the crew of each system conducting preventive maintenance checks and services, crews and mechanics troubleshooting broken systems, mechanics ordering replacement parts and repairing broken systems, and effective evacuation of broken systems. Medical operations include "buddy aid", provided by the crewmembers, and the actions of the units' combat lifesavers (soldiers that have been trained in first aid and CPR) and the attached combat medics.

Rehearsals are recorded as data in two ways: the O/C's subjective evaluation of the quality of the rehearsals conducted by the company team and the type of rehearsal that they conducted. The type of rehearsal that a company team conducts often depends on the tactical situation in terms of security and time available. Ideally, commanders want to conduct mounted rehearsals with their entire company teams. This is often impractical due to security concerns and conflicts with other preparation tasks. Other methods include mounted rehearsals with just key leaders, dismounted rehearsals, terrain model rehearsals, "FM" rehearsal (conducted on the radio), map rehearsals, and backbriefs. It seems logical that the more realistic the rehearsal and the higher the quality of the rehearsal, the more survivable the company team may be for the upcoming operation.

Boresighting is the process of aligning a weapon system with its sights. Unless a system is boresighted, the accuracy of the weapon's fire is impaired. Boresighting should be conducted frequently (two or three times daily) because weapons lose their boresight over time and as vehicles move and as weather conditions change. Also, due to parallax between the line of sight from the gunners' sights and the flight path of a round (or direct path of a MILES laser beam), the leaders must take care to boresight at the appropriate range – the range at which they expect to do most of their firing. Weapons systems that are not properly boresighted will be unable to destroy enemy systems; thus, we expect company teams that boresight poorly will be less survivable than those that boresight well.

Pre-combat inspections provide commanders and their subordinate leaders a chance to ensure that their unit is prepared for the upcoming mission. The items that are inspected vary from unit to unit and from mission to mission. Some units have standardized checklists to use as guides during these inspections. Some commanders state in their OPORDs the items they will inspect for that particular operation. In any event, a commander should take the opportunity to inspect those items within his company team that will give him an appraisal of his unit's readiness. Commanders will typically inspect maps to ensure that each tank and IFV has the maneuver graphics for the operation, the load plans to see that all necessary equipment within each system is properly stowed and readily available, the boresight of each system, and how well members of the tank and IFV crews understand the mission and the commander's intent for the operation. Commanders are taught to leave time after pre-combat inspections for their units to correct those items that did not meet his standards.

In terms of maintenance, this research considers the percentage of systems that each company team has available for each operation. This is called the operational readiness rate (OR rate). Although we do not penalize a company team in the MOE score for having a system that is unavailable for combat, we should examine the loss of that system on the survivability of the unit as a whole. We would expect units that are able to bring all of their systems into the battle are able to fight as a complete, cohesive unit and should be more survivable. However, it is also true that large units provide better targets. It could be that there is a negative correlation between OR rate and survivability. For

purposes of this study, OR rate at LD time for offensive and defend time for defensive battles will be collected. Future studies may want to examine the many tasks that support the OR rate, such as how well operators conduct preventive maintenance checks and services (PMCS), various ways that units organize their maintenance teams, how well they conduct recovery operations, and how quickly units are able to get repair parts.

To evaluate the execution phase, this research focuses on actions on contact, volume of fire, what systems are lost to what type of enemy, combat losses of leadership, and effects of enemy engagement areas. Other potential indicators, such as how well company teams communicate during the battle, their use of terrain, how well they maneuver, and their use of indirect fire are not currently evaluated at the company team level on a recurring, standardized basis and were, therefore, unavailable for this study.

Actions on contact are battle drills company teams execute when they first make contact with an enemy element. Different O/C teams at the NTC evaluate actions on contact differently. Two of the O/C teams subjectively evaluate the company teams on a "to standard" / "not to standard" basis. The other team evaluates all the opportunities within each company team and reports a percentage of actions that were conducted to standard over the battle as a whole. That evaluation team then report that company teams were successful if they acted properly in at least half of their opportunities. For all three O/C teams, the evaluators expect the company teams and their platoons to conduct actions on contact in accordance with their doctrinal manuals. That is, when a unit makes contact with an enemy unit it should first return fire, deploy, and report. It should then develop the situation by fire and maneuver. Finally, it chooses a course of action, such as conducting a hasty attack, bypassing, conducting an ambush, or fixing the enemy while the task force bypasses or assists in destroying that enemy [Ref. 6].

Volume of fire refers to the amount of ammunition the company team expends during the battle. The data are recorded as percentages of the basic load of ammunition that the company teams expended during the battle. If a unit keeps up a heavy volume of fire it seems reasonable that the enemy would have difficulty killing them and, thus, the company team would become more survivable. Also, a heavy volume of fire may cause a company team to become a more promising target for the enemy's direct and indirect fires.

22

In some cases, there could be a negative correlation between volume of fire and survivability.

The MILES system provides data on the type of enemy that kills each system, as shown in Table 1. This research attempts to determine if there is any correlation between survivability and the type of enemy that kills the company team.

A company team has as its leaders a commander, executive officer, platoon leaders, and platoon sergeants that constitute the unit's leadership within a battle. (The First Sergeant, while an important leader within the company team, focuses on other events during battles and is not taken to be a factor in terms of system survivability.) Logically, as company teams lose these key individuals, we would expect the units' survivability to decrease. For purposes of this research, we will define a company team as having *full leadership*, *degraded leadership*, or *lost leadership*. *Lost leadership* refers to company teams that are fighting without their commanders *and* with less than half of the subordinate leaders mentioned above. *Degraded leadership* refers to company teams that are fighting without their commanders *or* with less than half of the subordinate leaders mentioned above. *Full leadership* refers to company teams that have not suffered the losses of leadership that would put them in either of the other categories. To analyze this indicator, we examine the proportion of each battle that the company teams fight while in the above-described levels of leadership.

An engagement area is an area that a defending unit selects to destroy its enemies. A defending unit will typically use artillery, obstacles and deception to draw an enemy into its engagement area, and will then concentrate its direct fire assets toward killing the enemy there [Ref. 6]. In the execution phase, we would expect units that do the best job of avoiding and reacting to enemy engagement areas to be more survivable than others. Units that do not react well to enemy engagement areas typically lose a large portion of their systems in a short period of time. This research calculates the effects of engagement areas by dividing the duration of the highest concentration of a company team's losses by the duration of all of its losses. We use lower values for this ratio to signify units that suffered greater losses in engagement areas. The duration of the highest concentration of losses is the shortest time in which a company team suffered half of its losses. Logically, if

a company team was actually in an engagement area, it would suffer its losses more rapidly than when it was not in an engagement area. An example of the calculations from Alpha Team, TF 1-9 CAV (Appendix A) is as follows:

1. Alpha Team lost eight systems in total during the battle.
2. The shortest time span in which they lost four systems was from 1115 hours to 1125 hours, or 10 minutes.
3. They suffered their first loss at 0945 hours and their last loss at 1135 hours, 110 minutes apart.
4. The duration of highest concentration of losses over the duration of all losses is the ratio: 10 minutes / 110 minutes = 0.0909.

In addition to the indicators from the planning, preparation and execution phases, there are indicators that will remain constant throughout the operation. The first indicator is the type of operation conducted – offensive or defensive. It is reasonable to surmise that different indicators may be relevant for the different types of operations. The second indicator is the type of mission assigned to the company team by the task force commander. One company team within a task force is always designated as the main effort. As such, it is often the company team that the task force commander perceives as the strongest. Because of being used as the main effort, it will likely be placed in a position to suffer greater losses than the supporting effort company teams.

The effect of task organization on survivability is also considered. Tanks are designed to have greater survivability than IFVs, and we should account for that when analyzing survivability. We expect tank companies and tank heavy teams to have higher survivability rates than mechanized companies and mech heavy teams. Also, we should examine the effect of team size on survivability – do teams with more or less than the usual three platoons have different survivability levels? This research investigates this question. There are ten common task organizations for company teams. To gain the most information from these task organizations, three aspects of each are considered:

1. What is the primary system: Tank, IFV, or is the team Balanced?
2. How big (relative to the normal three platoons) is the company team?
3. Has the company team received attachments?

Table 2 shows how each of the ten most common task organizations were assigned in terms of the questions above.

Task Organization (Tank Plts., IFV Plts.)	Primary System (Tank, IFV, Bal.)	Size (Norm, Lg., Sm.)	Attachments (Pure, Att.)
3,0	Tank	Norm.	Pure
2,1	Tank	Norm.	Att.
3,1	Tank	Lg.	Att.
2,0	Tank	Sm.	Pure
0,3	IFV	Norm.	Pure
1,2	IFV	Norm.	Att.
1,3	IFV	Lg.	Att.
0,2	IFV	Sm.	Pure
2,2	Bal.	Lg.	Att.
1,1	Bal.	Sm.	Att.

Table 2. Task Organizations and Categorical Indicators

B. DATA COLLECTION

Data were collected for this research from November 1997 to February 1998 and covered four active duty brigade rotations at the National Training Center. It observed seven task forces (four armored, three mechanized infantry) and 25 company teams (13 armored, 12 mechanized infantry) from three CONUS active duty installations as they conducted 28 task force and 88 company team battles. The three installations that were represented were Fort Riley, Kansas; Fort Hood, Texas; and Fort Stewart, Georgia. The units did not include any from outside the Continental United States, did not include any divisional or regimental cavalry squadrons, did not include any light forces, and did not include any reserve component units. Any generalizations and conclusions that are drawn from this research can naturally be extended to other active duty forces; however, the same is probably not true for light, cavalry, and reserve component units. Light units operate in a vastly different way, conducting some different forms of maneuver in offensive operations as well as some different forms of the defense. As stated earlier, any

study of light forces is better conducted at the JRTC at Fort Polk, Louisiana. Cavalry units do not typically attack and defend, as armored and mechanized infantry task forces do. Instead, they screen, guard, and cover. Just as we would expect different indicators to be most significant for an armored or mechanized company team in offensive and defensive operations, we could expect different indicators to be most significant for the cavalry troops in their differing missions. Also, cavalry troops are organically structured with a complement of tanks and cavalry fighting vehicles (very similar to the infantry fighting vehicles). They do not suffer the oft-changing task organizations of the company teams. In the case of reserve component units, their vastly different mission essential task lists (METLs) and restricted training time cause them to have different priorities and training backgrounds than the active duty units. We would logically expect to find different answers to the research questions if we examined reserve component units.

The climate for this research was typical desert winter conditions: warm in the daytime (high temperatures typically between 55 and 75 degrees Fahrenheit), cool at night (low temperatures from 20 to 40 degrees), occasional high winds (gusts up to 40 miles per hour), and little precipitation. The terrain at the NTC is open and mountainous. There is much open terrain with freedom to maneuver and conduct long range direct fire engagements, but there is also considerable terrain that is restricted to maneuver forces by a complicated wadi system and some terrain that is closed to maneuver by the mountains. Conclusions from this research can be equally applied to any weather conditions that are not unusually hostile and in other environments that allow weapons systems some freedom to maneuver and conduct long range engagements. The conclusions should not be considered viable for heavy task forces conducting operations in a jungle climate.

The subjective data for the research come primarily from observations by the company team O/Cs, with assistance from their platoon O/Cs. For each operation, the O/Cs travel along side and within the company teams from the time they receive their task force operations order, through the company teams' planning, preparation, and execution of their missions, and ultimately into the consolidation and reorganization which occurs at the end of each mission. Approximately two hours following the end of each battle, the company team O/Cs conduct their AARs with the commanders and, usually, the other key

26

leaders within the company team. Typically, the company team O/Cs relay their observations to the task force O/Cs at two different times during the operation. First, at some time when each company team has completed the planning phase and is well into the preparation phase, the task force O/Cs will meet with all their company team O/Cs to hear their evaluations. This allows the task force O/Cs to ensure that the evaluations follow acceptable standards for each team. In other words, they ensure that those company teams that receive a "to standard" rating on a task actually met the standards and performed the task better than those that received a "not to standard" for the same task. The O/Cs meet again shortly after the execution phase for the same purpose.

Once the task force and company team O/Cs have discussed each task evaluation, the evaluations are relayed to the Tactical Analysis Facility (TAF). At the TAF each company team has an integrator who collects the data for his company team. There is also a task force integrator who ensures valid and complete data collection across the task force. He further consolidates the data and makes task force AAR reports that show how well each element of the task force performed during the planning, preparation and execution phases of the operation.

The subjective data that are collected through the above methods are the following:

- Warning Order
- Graphics
- Operations Order
- Direct Fire Plan / Execution
- Security Operations
- Combat Service Support
- Risk Assessment
- Rehearsal Quality
- Boresight
- Pre-combat Inspection
- Actions on Contact

The objective data that are collected through the above methods follow:

- Timeline
- Type of Rehearsal
- Time of Loss for a System
- Cause of Loss for a System
- Volume of Fire
- Effects of Engagement Areas
- Loss of Leadership

The O/Cs and the TAF integrators working together gather time and cause of loss for a system. When a system is lost during a battle, either the O/C knows about it when he sees the system's "whoopee" light flashing, the TAF integrator will notice the system's icon on his screen turn from blue to black or gray, or both. These two sources of information provide enough redundancy to ensure accurate data collection. They communicate to each other the time of loss. Then the O/C inspects the "brain box" on the system's MILES to determine the cause of the loss. He relays this information to the TAF analyst. The O/C also inspects the brain box of all systems at the conclusion of the battle to determine how many rounds were fired. This is also relayed to the TAF for calculation of the volume of fire.

The TAF analysts collect all of the above information in two places: the task force AAR reports and the company team battle damage assessment (BDA) reports. From the BDA reports we can also gather the task organization and operational readiness rate by observing how many platoons of each system type were assigned to each company team and what percentage of those systems actually started the battle.

There are potential sources of error in the collection of these data. These stem from the typical causes of human error. Different O/Cs and integrators will perform differently in collection of the data. The three teams that were used to gather these data collect and evaluate some tasks differently from each other. Some of the differences were mentioned in the discussion of indicators above. However, each potential indicator deserves a brief discussion of potential errors:

- Warning Order and Graphics. One of the three task force O/C teams does not specifically address WARNORDs. However, the purpose of these two

indicators is to address how well company teams perform in the earliest stage of planning and its impact on survivability. Also, most company teams (78 percent) evaluated by the other O/C team either met the standard on both tasks or failed to meet the standard on both. For this combined indicator, the company teams were evaluated as follows: from the O/C team that only evaluated graphics, company teams that met the standard were given a "1" and those that did not were given a "0"; from the O/C teams that evaluated both, company teams that met the standard on both were given a "1", those that met the standard on only one were given a "1/2", and the others were given a "0". The three task force O/Cs enforced standards. However, since this task often gets overlooked in favor of the OPORD during the planning phase, it is possible that O/Cs might give company teams the benefit of the doubt and report that they were "to standard" without having actually made an observation.

- Operations Orders. These were evaluated subjectively by the O/Cs. Standards were enforced by the task force O/Cs who conducted detailed discussions with the assembled company team O/Cs.

- Risk Assessment. These were evaluated subjectively by the O/Cs. Risk assessment has eight subordinate tasks that each of the O/C teams use to arrive at a single evaluation. The task force O/Cs enforce the standards. However, like the WARNORD, risk assessment's repetitive nature might cause O/Cs to give units the benefit of the doubt once they meet the standard.

- Timeline. These are objective data that are relayed from the O/Cs to the TAFs. The reported numbers are most assuredly accurate. With timeline percentages, however, the numbers do not always tell the whole story. For example, if the one-third / two-third rule recommends issuing an OPORD at 0300 hours, perhaps the commander is better advised to let his key leaders get some rest before issuing them an order to which they must pay very close attention. For the battles observed for this research, 97 percent had a recommended time of OPORD issue (by the one-third / two-third rule) during daylight hours.

- Direct Fire Plan / Execution. As explained earlier, the three teams evaluate this area differently. There is some potential for error because two teams focus their evaluation on the planning phase and the other focuses on the execution phase. Any conclusions drawn about this indicator must take that into consideration.

- Security Operations. This is another subjectively evaluated indicator. Because security operations are broad in scope, including everything from how disciplined the unit is while maintaining night watches to their placement of chemical alarms to how vigorously they conduct reconnaissance and security patrols, the different O/C teams may observe and focus on different aspects of security. Also, BLUEFOR units that come for training typically perform security tasks poorly during the first few days, and then show improvement as the rotation progresses. Once the unit improves, the O/Cs' attention may be more focused on other preparation tasks, which may causes inflated, or benefit of the doubt, evaluations for security operations later in a rotation.

- Combat Service Support. Similar to security operations, this subjectively evaluated area tends to show improvement over the course of a rotation. The impact on unit survivability might be hidden by the fact the units generally do a poor job with CSS operations early in the rotation and better later.

- Rehearsal Quality. Like the OPORD, the O/Cs monitor the rehearsals very closely. They view this task, along with boresighting, as the most important preparation phase task. There is no obvious source of error here; however, there is a great potential for interaction between rehearsal quality and rehearsal type. If the company team conducts a map rehearsal when there is obvious opportunity and potential benefit to have a mounted rehearsal, the O/C is likely to assess the rehearsal quality as "not to standard". This is not necessarily a reflection of how well the company team conducted the map rehearsal, but more a reflection of the lost opportunity to conduct a higher level of rehearsal.

- Boresight. This task has potential for "benefit of the doubt" assessment during the middle battles of the rotation. The O/Cs are quite focused on this task

during the beginning of the rotation and during the live fire battles (which occur at the end of the rotation). However, once units show competence in the conduct of boresighting their MILES systems for the force-on-force battles, the O/Cs might not check it every time in favor of concentrating on other tasks.

- Pre-Combat Inspection. This task is another that typically improves over the course of a rotation. Therefore, once the company team shows proficiency in the conduct of their PCIs, the O/Cs might not actually evaluate this task every time, but instead rate them as "to standard".

- Actions on Contact. As explained earlier, the three O/C teams evaluate this area differently. Like the direct fire plan, this task also has potential for spill over between the planning and execution phases of the operation. Different O/Cs will evaluate this task during different phases. Any conclusions drawn about the impact of this task on survivability should take into consideration that some of the data are taken from different phases of the operation. When determining which indicators in the planning and execution phases have the strongest correlation with survivability, any conclusions about actions on contact must take this into account.

- Rehearsal Type. Different O/C teams categorize the types of rehearsals differently from each other. For purposes of this research, the O/C categorizations have been assembled to represent mounted rehearsals, walk-through rehearsals, "check-the-block-rehearsals" (which include map, brief-back and FM rehearsals), and "none" (no rehearsal was conducted). This should allow for a simpler analysis, without considering the details of what proportion of the unit participated in the rehearsal. Those concerns are impossible to adequately assess with the given data and, furthermore, the assessments should manifest themselves in the subjective assessment of the quality of the rehearsal.

- Time of Loss for a System. Some company team TAF integrators simply do a better job of recording this information than others during the course of a

battle. There are several potential causes for this. Some TAF integrators are assigned additional units – such as the task force scout platoon – to keep track of as well, resulting in information overload during a fast paced battle. Also, time of loss for each system was requested specifically for this research. Other projects, including the Advanced Warfighting Experiment have required these data for analysis. However, because this is not routinely gathered information, some (three of twelve) TAF integrators did an inconsistent job of collecting the information. Often, a missing time of loss entry was easily estimated – if a platoon lost two systems to artillery at 10:15 and they lost a third system to artillery at an unknown time, we can estimate that the system was lost in the same artillery barrage at 10:15. The impact on such estimates is slight due to the scaling of the MOE. They are not likely to move a unit from the status of most survivable to a lower status, or vice versa. For battles in which a TAF integrator did such a poor job of recording times of loss that estimation was not possible, that company team was eliminated for consideration for that battle and the task force was considered to be one company team smaller. When this happened to an already small task force, the battle was removed from consideration.

- Cause of Loss for a System. Some O/Cs report the MILES kill code during the battles, while others report the specific type of system that caused the loss. There is some conflict between anti-tank missile kills and the identification of the system which launched the missile. For example, an AT-5 that is launched from a BMP2 gives a 07 kill code, while the same missile from a BRDM gives a 08 kill code. Further, BMPs have five different kill codes from their various weapons. Because of the higher prevalence of BMPs over BRDMs on the battlefield, if the cause of loss was in doubt between these two, the BMPs were given credit for the loss. Also, the entry for enemy air kills includes both fixed and rotary wing aircraft. Entries from many TAF integrators do not distinguish which type of aircraft caused the loss. To alleviate these errors and allow for more generalized answers to the research questions, this research groups the

causes of loss into four categories: direct fire, indirect fire, minefields, and maintenance.

- It should be noted that for live-fire battles, both Time of Loss and Cause of Loss for systems are selected by the O/Cs and not by an enemy. Because this can be somewhat arbitrary, all data from live-fire battles were eliminated for purposes of this research.

- Operational Readiness Rate. Most TAF integrators record maintenance losses during the battle as different from systems that never entered the battle because of maintenance. For the former, the OR rate is the most accurate. There is potential for error, however, when the records make it unclear whether a system entered the battle and later broke down or was not able to enter the battle. Cross-references with the task force reports usually clarify this; however, about 10 percent of the reports required an estimate of the OR rate for a particular company team. This estimate was typically in the neighborhood of 7 to 10 percent in magnitude.

- Volume of Fire. The O/Cs and TAF integrators recorded these data faithfully and accurately. The potential for erroneous conclusions comes with the differing volumes of fire for different types of missions and different types of battles. Specifically, company teams fire more ammunition in defensive battles than when they attack because there are more enemy units to engage in defensive operations. Also, tanks typically fire more of their ammunition than IFVs. Any conclusions drawn about volume of fire must take into consideration mission type and task organization.

- Effects of Engagement Areas. In theory, only an attacking unit will be subject to the effects of an enemy engagement area. This research pursues this analysis for both attacking and defending units, however, on the assumption that the principles will remain the same. In other words, attacking units who lose the bulk of their systems in a short span of time are considered to have been diminished by an enemy engagement area. The analysis shows that units should have modified their schemes of maneuver appropriately to counter the effects

of the engagement areas. Similarly, defending units that lose the bulk of their systems rapidly should have also modified their defensive schemes of maneuver to preserve their systems. That said, this research determines whether this indicator is significant in either offensive or defensive operations, or both.

- Loss of Leadership. There are two obvious sources of error with this indicator. First, this research presumes that if a leader's system is unavailable for the battle, the leader has moved to his wing system. This is probably true for platoon leaders and platoon sergeants but is more questionable for commanders and executive officers. Commanders and executive officers do not have wingmen and will typically move to some designated system within the company team. Which systems the commander and executive officer move to vary from unit to unit and from battle to battle. This research assumes that commanders move to their executive officers' systems (which is probable) and that executive officers are not in the battles. An executive officer whose system is not available will probably move to one of the six wing systems in the company team. However, predicting which of the six systems is impossible. Second, this research presumes that once their systems die in battle, the key leaders are no longer available. Although this seems logical, it is not always true. Sometimes, a lost system is assessed a lesser amount of damage and the leader is allowed to jump to another system. Unfortunately, the frequency of this varies significantly among the O/C teams and no records of these occurrences are kept. Still, even when a key leader moves to a new system, he is generally out of the battle for some period of time (typically 15 to 60 minutes) and his unit will feel the effects much as if he were permanently lost.

C. DATA ANALYSIS

To analyze the relationships between the various indicators and survivability, this research includes separate analyses to answer each of the six research questions from Chapter II. Several of the research questions are best answered by dividing the company teams into two categories – "more survivable" and "less survivable". All company teams with MOE > 0.65 are said to be more survivable; all company teams with MOE < 0.65 are

said to be less survivable. The break point of 0.65 was chosen for two reasons. First, this is the location of the largest break in the MOE scores for this data set. No company teams received MOE scores that were less than 0.67 and greater than 0.63. Also, it places only the lowest 23 of the 88 data points (just over 25 percent) in the "less survivable" category. Figure 2 demonstrates that division.

Scatter Plot of Scaled MOE
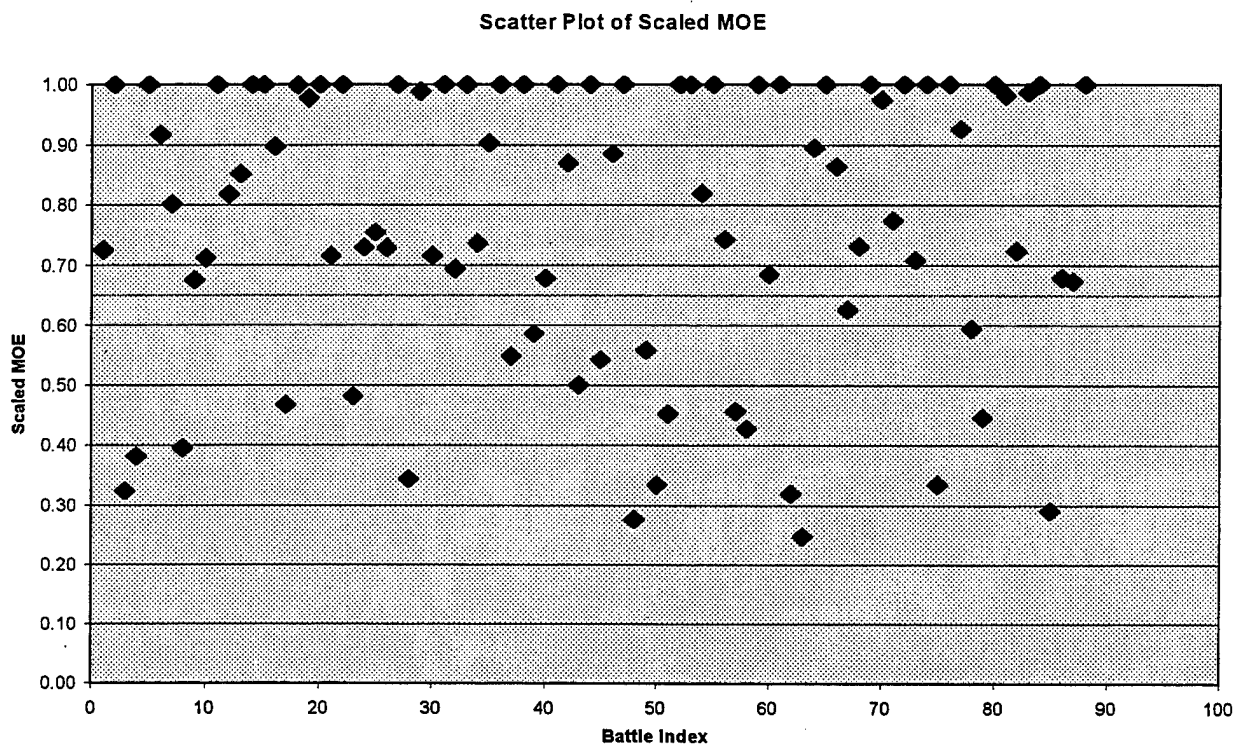
Figure 2. Scatter plot of Scaled MOE. The dashed line represents the break between more and less survivable company teams at MOE = 0.65.

Research Question 1: "In each of the three phases of an operation – planning, preparation, and execution – what tasks, when performed to standard, are most indicative of a company team that is more survivable than others?"

For each phase we need to determine which indicator has the most significant relationship with survivability. To do so we use three analytical tools: regression trees, classification trees, and linear models – all of which are available in S-Plus. For each of these, the MOE developed in Chapter III (the scaled average of the time that each system in the company team survived the battle) is the dependent variable and the various indicators discussed earlier in this chapter are the independent variables.

S-Plus builds trees as follows:

1. It starts at the root, which contains all the data. The tree in Figure 3, for example, shows the root at the top. In the node is the value "0.76", which is the mean MOE score for all of the data. The value below the node, 3.400, is the total deviance of the tree to that point. (Deviance is defined later in this section.)

2. S-Plus then considers all the independent variables and all the potential splits to find the variable and split that will reduce the deviance the most. Continuing with Figure 3, note that S-Plus selected the independent variable "Timeline" and the split at 0.345. This means that all company teams with Timeline < 0.345 are now grouped together in the node with value "0.66" – this is the mean MOE score for those units. The company teams with Timeline > 0.345 are grouped in the node with value "0.85". Note that the sum of the two deviances (1.800 and 1.100) shown below the nodes gives a tree with total deviance 2.900. This is lower than the previous deviance. No other choice of independent variable or location to split Timeline would have resulted in a lower total deviance for the tree to this point.

3. S-Plus then repeats the process for each node. That is, the left node with deviance 1.800 is split into two nodes with the greatest reduction in variance, as is the right node with deviance 1.100. It will continue to repeat the process, considering all possible branches from all possible nodes.

4. S-Plus will stop the process only when a node is pure (i.e. all MOE scores in the node are equal) or when the data are too sparse (in this case, when the data cannot be broken into groups larger than five). Once that occurs, the node is called a terminal node or "leaf" and is represented by a rectangle. S-Plus will not consider creating any branches from the leaves.

5. The tree is complete when there are no more branches to make. The resulting tree has all terminal nodes. The sum of the deviances shown below the leaves is the total deviance for the tree. Note that the total deviance for the tree in Figure 3 is 1.510, which is well below the original deviance of 3.400.
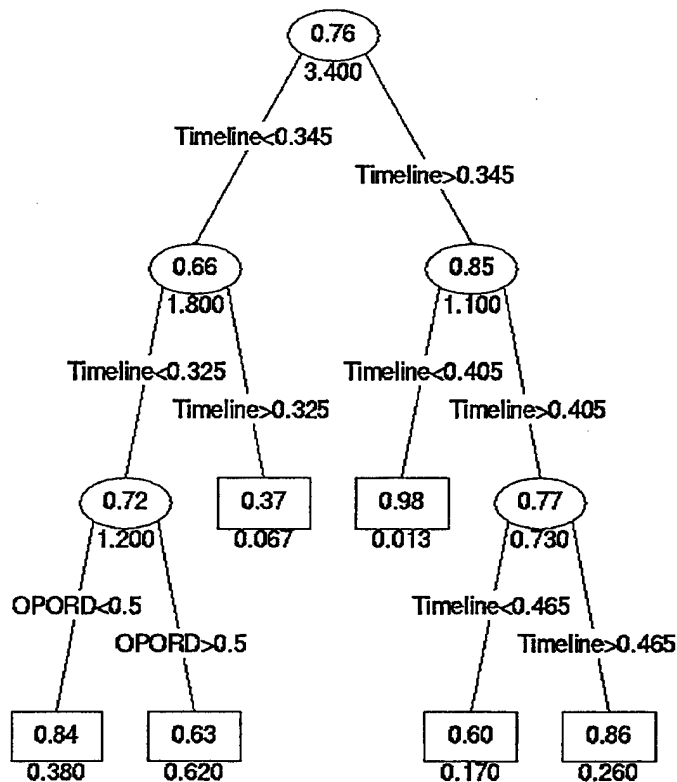
Figure 3. Regression tree for planning phase.

Simply put, for the regression trees and classification trees, the root nodes (at the top) split on the most significant indicators. Leaves predict the MOE score depending on the values of the independent variables above the leaf. For example, the leaf that has value "0.37" in Figure 3 predicts that company teams that have Timeline values less than 0.345 and greater than 0.325 will have an MOE score of 0.37. The deviance is a measure of how good that prediction may be.

Regression trees offer predicted MOE scores for each leaf of the tree. They are built using the MOE scores as the dependent variables. Classification trees predict whether the company teams will be "more survivable" or "less survivable." The dependent variables for classification trees are either "1" for more survivable or "0" for less survivable.

Deviance of a node is the total sum of squared differences between the MOE scores in the node and the mean MOE score for the node. This is calculated by taking the difference between the mean MOE score for the node and the MOE score for each data

point, squaring it, and adding it to the other squared differences for the data set. For the entire 88-line data set, the mean MOE score is 0.77. The total deviance is 4.870. This means that the total squared differences between each MOE score and 0.77 is 4.870. (The mean and deviance are somewhat different in Figure 3 because this particular tree uses only 57 lines of data. The lines with missing observations were not used.)

For each tree used in this research, a cross-validation was performed. Cross-validation seeks to find the right size tree – the size that does not over-fit the data and has good predictability. Cross-validation randomly splits the data into ten (roughly) equal parts. Part 1 is withheld and trees are built using the other 90 percent of the data. Trees are built for sizes 1 (one terminal node), 2, 3, etc. The data values that were withheld are then dropped down the tree of each size, each value landing in a leaf giving a prediction for each. The deviance of these predictions is computed. This process is repeated for Part 2 of the data, then Part 3, etc., until all ten parts have been considered. The result is a plot showing the size of the tree vs. the minimum deviance of the ten trees constructed of that size. Figure 4 shows a plot of the output of S-Plus's cross-validation method for the tree shown in Figure 3. The bottom axis refers to the size of the tree measured by the number of leaves. The vertical axis shows the minimum deviance for the tree of corresponding size. Since the goal is to create the right sized tree, we choose to "prune" the tree to have size = 6. By pruning the tree we get a model with less deviance that still offers good predictive ability. The top axis displaying the values of the sequencing parameter for each tree was not used in this analysis.
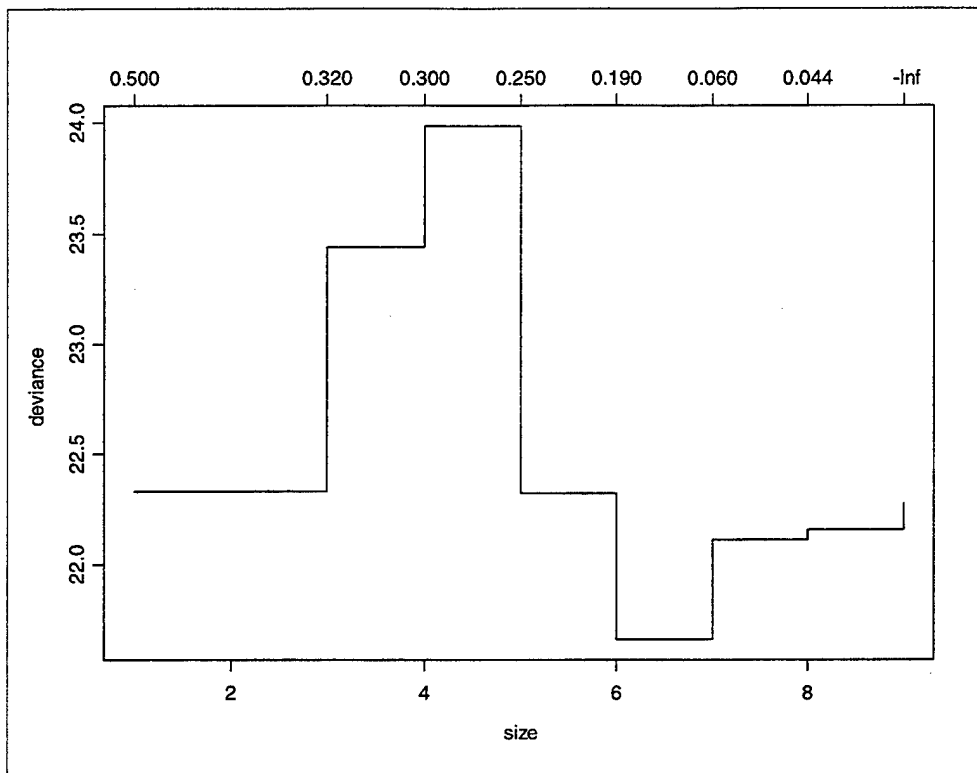
Figure 4. Example of a cross-validation plot of a regression tree.

For each part Research Question 1, the regression and classification trees showed the same indicators as most significant; therefore, only the regression trees are shown. Later research questions will show both types of trees.

Linear statistical models were examined using the S-Plus `stepwise` function. The `stepwise` procedure uses an exhaustive search to identify a set of independent variables to include in a least squares multiple regression. This research used the forward procedure with a maximum size of one. (Later research questions will use different maximum sizes, which will be explained at that time.) Thus it will return the single independent variable that has the largest impact on the value of the dependent variable (MOE score). Each phase below includes a summary of the linear model made from the single indicator.

For the planning phase, trees and linear models were made using MOE score as the dependent variable and the following indicators as the independent variables:

- Warning Order / Graphics

- Operations Order

- Risk Assessment

- Timeline

- Direct Fire Plan

The analysis was performed twice – with and without Timeline – because 34 percent of the data points do not include values for Timeline. The analysis with Timeline examined 57 company teams and the analysis without considered 86 company teams. (Even with Timeline removed, there were still two company teams excluded due to incomplete data.)

Figures 3 and 5, respectively, show the size = 6 regression tree and linear model for the planning phase (including Timeline). They show the following:

- Regression tree:

   - Timeline < 0.345 predicts an MOE score of 0.66. This includes 27 of the 57 cases.

   - Timeline > 0.345 predicts an MOE score of 0.85. This includes 30 of the 57 cases.

- Linear model: Risk Assessment is most significant. However, notice that the p-value for the indicator is 0.1342. This tells us that, although risk assessment is more indicative of survivability then the other independent variables, risk assessment by itself is still not a significant indicator of survivability.

```
> summary(rq1plan.lm)

Call: lm(formula = MOE3 ~ Risk, data = RQ1Plan1)
Residuals:
      Min        1Q       Median       3Q          Max
    -0.5379    -0.159     0.03255     0.2148      0.3284

Coefficients:
                Value     Std. Error    t value     Pr(>|t|)
(Intercept)     0.6716    0.0649        10.3514     0.0000
       Risk     0.1136    0.0747         1.5202     0.1342

Residual standard error: 0.2428 on 55 degrees of freedom
Multiple R-Squared: 0.04032
F-statistic: 2.311 on 1 and 55 degrees of freedom, the
       p-value is 0.1342
```

Figure 5. Linear model of the planning phase.

Thus, for the planning phase (considering Timeline) the most significant indicators of survivability are Timeline Utilization and Risk Assessment. There are two surprises here. First, although it is not surprising that Timeline is most significant among the planning phase indicators, it is surprising in what it predicts. It shows that, for this data set, company teams that used more of their timeline than the recommended 33 percent actually were more survivable in the battles. One possible explanation for this has to do with what those more survivable company teams were doing prior to the issuance of the OPORD. One could reasonably assume that the more survivable company teams actively begin the preparation phase prior to receiving their OPORD. They can conduct maintenance, boresighting, and pre-combat inspections early if the commander needs more time to prepare the OPORD. Also, the commander might delay the OPORD to conduct reconnaissance that will allow for a better prepared OPORD. Second, we typically presume Risk Assessment to be less indicative of battle actions than the other available indicators. That a linear model would show it as most significant can best be attributed to the actual evaluations. Most of the company teams (78 percent) performed risk assessment to standard. Those few that were not to standard were generally below standard in many other tasks and, subsequently, were not very survivable during those battles.

Figures 6 and 7, respectively, show the size = 3 regression tree and linear model for the planning phase (excluding Timeline). They show the following:

- Regression tree:
    - Risk Assessment < 0.5 predicts an MOE score of 0.71. This includes 18 of the 86 cases.
    - Risk Assessment > 0.5 predicts an MOE score of 0.78. This includes 68 of the 86 cases.
- Linear model: Risk Assessment is most significant.
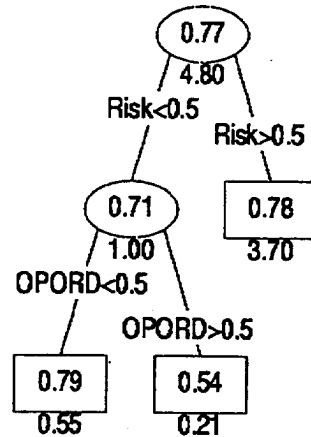
Figure 6. Regression tree for planning phase (without Timeline).

```
> summary(rq1plan2.lm)

Call: lm(formula = MOE3 ~ Risk, data = RQ1Plan2)
Residuals:
     Min        1Q      Median        3Q        Max
   -0.5359   -0.1419    0.05065    0.2168     0.2926

Coefficients:
              Value      Std. Error    t value    Pr(>|t|)
(Intercept)   0.7074     0.0559        12.6615    0.0000
       Risk   0.0758     0.0628         1.2072    0.2307

Residual standard error: 0.237 on 84 degrees of freedom
Multiple R-Squared: 0.01705
F-statistic: 1.457 on 1 and 84 degrees of freedom, the
     p-value is 0.2307
```

Figure 7. Linear model of planning phase (excluding Timeline).

Risk Assessment is again the most indicative of survivability among planning phase indicators. Although this is somewhat surprising, one explanation is available in the previous section (from the linear model of the planning phase – including Timeline). Another explanation has to do with the predictive ability of these particular models. The tree predicts MOE scores of 0.71 and 0.78 depending upon Risk Assessment, but those scores are relatively close. Note also that the total deviance of the tree dropped only 0.10 (from to 4.80 to 4.70) after the first split. Also note that the p-value in the linear model (0.2307) is well above the rejection value of 0.05. These predictions are simply not very

helpful. All they really tell us is that this data does not support an adequate answer to the research question.

For the preparation phase, trees and a linear model were made of the MOE score with respect to the following indicators:

- Security Operations
- Combat Service Support
- Rehearsal Quality
- Rehearsal Type
- Boresight
- Pre-Combat Inspection
- Maintenance (Operational Readiness Rate)

Figures 8 and 9, respectively, show the size = 2 regression tree and linear model for the preparation. They show the following:

- Regression tree:
  - Secure < 0.5 predicts an MOE score of 0.68. This includes 37 of the 79 cases.
  - Secure > 0.5 predicts an MOE score of 0.84. This includes 42 of the 79 cases.
- Linear model: Secure is most significant.
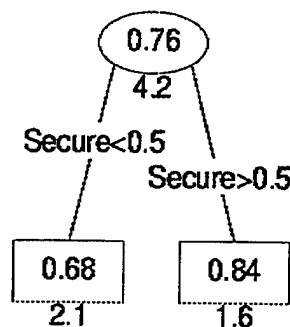
Figure 8. Regression tree for preparation phase.

```
> summary(rq1prep.lm)

Call: lm(formula = MOE3 ~ Secure, data = RQ1Prep)

Residuals:
    Min        1Q        Median      3Q         Max
    -0.5932    -0.1223    0.02347    0.1595      0.3212

Coefficients:
              Value     Std. Error    t value    Pr(>|t|)
(Intercept)   0.6788    0.0362        18.7716    0.0000
     Secure   0.1617    0.0496        3.2602     0.0017

Residual standard error: 0.22 on 77 degrees of freedom
Multiple R-Squared: 0.1213
F-statistic: 10.63 on 1 and 77 degrees of freedom, the
     p-value is 0.001659
```

Figure 9. Linear model of preparation phase.

The models clearly show Security Operations as most indicative among the preparation phase tasks of survivability. This is somewhat surprising, since O/Cs at the NTC stress boresight and rehearsal quality as the most important tasks to perform well during the preparation phase. One possible explanation follows in answer to Research Question 3.

For the execution phase, trees and a linear model were made of the MOE score with respect to the following indicators:

- Actions on Contact

- Volume of Fire

- Effects of Casualties Among the Leadership (PerLost, PerDeg, PerFull, and LostB4Cdr)

- Effects of Enemy Engagement Areas

- Causes of Loss of Systems (Direct Fire, Artillery, Mines, Maintenance)

Similar to the planning phase, the execution phase was examined twice, with and without Actions on Contact. For 17 percent of the data, Actions on Contact evaluations were not available.

Figures 10 and 11, respectively, show the size = 3 regression tree and linear model for the execution phase (including Actions on Contact). They show the following:

- Regression tree:

  - PerLost < 0.24 predicts an MOE score of 0.91. This includes 29 of the 65 cases.

  - PerLost > 0.24 predicts an MOE score of 0.63. This includes 36 of the 65 cases.

- Linear model: PerLost is most significant.

Figure 10. Regression tree of the execution phase.

```
> summary(rq1ex1.lm)

Call: lm(formula = MOE3 ~ PerLost, data = RQEx1)

Residuals:
     Min       1Q      Median       3Q         Max
   -0.4328  -0.1318  0.05324      0.1387      0.4267

Coefficients:
              Value     Std. Error    t value    Pr(>|t|)
(Intercept)   0.9248    0.0406        22.7688    0.0000
    PerLost  -0.4573    0.0859        -5.3267    0.0000

Residual standard error: 0.2028 on 63 degrees of freedom
Multiple R-Squared: 0.3105
F-statistic: 28.37 on 1 and 63 degrees of freedom, the
     p-value is 1.426e-006
```

Figure 11. Linear model of execution phase (including Actions on Contact).

Thus, for the execution phase (including Actions on Contact), the effect of casualties among the leadership is clearly the most significant. In other words, those company teams who are able to fight the battles with the lowest proportion of time coming after leadership (commanders, executive officers, platoon leaders, and platoon sergeants) is lost are more survivable. Conversely, company teams that fight higher proportions of the battles with the full complement of their leadership alive are more survivable. This is not surprising at all and will be addressed further in Chapter V.

Figures 12 and 13, respectively, show the size = 4 regression and linear model for the execution phase (excluding Actions on Contact). They show the following:

- Regression tree:
    - PerFull < 0.43 predicts an MOE score of 0.65. This includes 47 of the 82 cases.
    - PerFull > 0.43 predicts an MOE score of 0.92. This includes 35 of the 82 cases.
- Linear model: PerFull is most significant.

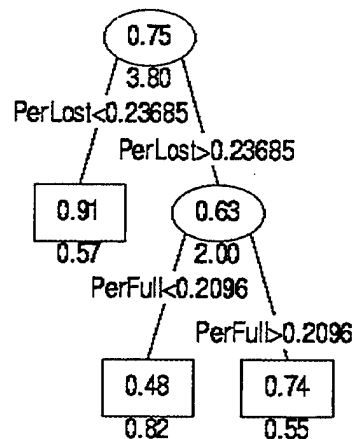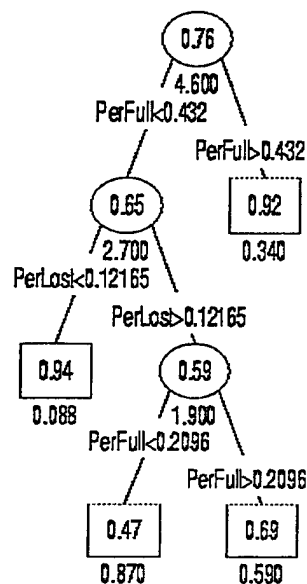Figure 12. Regression tree of execution phase (excluding Actions on Contact).

```
> summary(rq1ex2.lm)

Call: lm(formula = MOE3 ~ PerFull, data = RQEx2)
Residuals:
     Min        1Q       Median      3Q        Max
    -0.3818   -0.121    0.0002016   0.1015    0.4392

Coefficients:
               Value     Std. Error    t value    Pr(>|t|)
(Intercept)    0.5413    0.0401        13.4972    0.0000
    PerFull    0.5269    0.0804         6.5575    0.0000

Residual standard error: 0.1937 on 80 degrees of freedom
Multiple R-Squared: 0.3496
F-statistic: 43 on 1 and 80 degrees of freedom, the
      p-value is 4.957e-009
```

Figure 13. Linear model of execution phase (excluding Actions on Contact).

Excluding Actions on Contact does not change the answer to Research Question 1 for the execution phase. The effect of casualties among the leadership remains the most significant among execution phase indicators; however, the larger sample allows for greater confidence in this answer.

Research Question 2. "In which of the three phases is successful task performance most indicative of a more survivable company team?"

This question required closer examination of each phase for each battle. To assess performance within each phase, we need to determine the company teams' performance relative to each other. To do so, this research assessed the company team that performed the tasks for a given phase better than the other company teams from the same task force as being the best for that battle. Each task was considered to be of equal importance – in other words, they were equally weighted with respect to each other. That company team that was assessed as being the best was then given a score of "Best" for that phase of the operation. Similarly, the company team that performed the tasks worse than the others for that phase was assessed as the worst company team for that phase and given a score of "Worst". The remaining company teams were given scores of "Mid". This assignment system rendered scoring results as shown in Table 3.

Company Teams in the Task Force	Best-to-Worst Scores Assigned
2	Best, Worst
3	Best, Mid, Worst
4	Best, Mid, Mid, Worst
5	Best, Mid, Mid, Mid, Worst

Table 3. Description of phase scoring for Research Question 2.

Table 4 gives an example of how one task force battle was examined to assign scores for the preparation phase. Notice that Bravo Team performed better than or equal to the other teams in every task except rehearsal type (their dismounted rehearsal was an inferior type to Alpha Team's mounted rehearsal, but better than Charlie and Delta Teams' check-the-block rehearsals). Thus, Bravo Team was assigned a preparation phase score of "Best", which is seen in the right-most column. Also notice that Charlie Team performed worse than or equal to the other teams in every task except maintenance (OR Rate). Thus, Charlie Team was assigned a preparation phase score of "Worst". The other company teams were assigned scores of "Mid" for the preparation phase.

Co.Tm	Secure	CSS	RehQual	RehType	Boresight	PCI	OR Rate	**Prep**
Alpha	0	0	1	M	1	0	0.67	**Mid**
Bravo	1	1	1	D	1	0	1.00	**Best**
Charlie	0	0	0	C	1	0	1.00	**Worst**
Delta	1	1	0	C	1	0	0.79	**Mid**

Table 4. Example of scoring assignments for a single phase.

To determine which phase was most indicative of survivability, this research also used trees and linear models. Again, cross validation was used to determine the best tree size and `stepwise` was used to chose the proper independent variable for the linear model. The resulting regression tree is shown in Figure 14 and the resulting linear model is shown in Figure 15. For both of these, the MOE score was the dependent variable and the

three assigned scores for the phases were the independent variables (called Plan, Prep, and Ex).
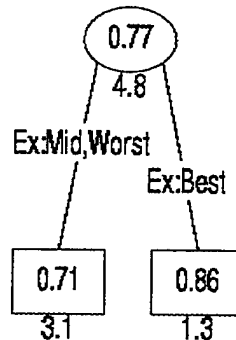
Figure 14. Regression tree of MOE with respect to performance in the 3 phases.

```
> summary(rq2C.lm)

Call: lm(formula = MOE3 ~ Ex, data = RQ2C)
Residuals:
      Min        1Q      Median        3Q         Max
    -0.5673   -0.1483    0.03922     0.142      0.3018

Coefficients:
              Value      Std. Error     t value    Pr(>|t|)
(Intercept)   0.7623     0.0252         30.2285    0.0000
       Ex1   -0.0636     0.0320         -1.9908    0.0498
       Ex2   -0.0320     0.0172         -1.8637    0.0659

Residual standard error: 0.229 on 83 degrees of freedom
Multiple R-Squared: 0.0941
F-statistic: 4.311 on 2 and 83 degrees of freedom, the
     p-value is 0.01655
```

Figure 15. Linear model of MOE with respect to execution phase performance.

Both models show that performance in the execution phase is most indicative of a more survivable company team. The regression tree, specifically, shows the following:

- Company teams that perform the best in the execution phase can expect an MOE score of 0.86. Those that perform the worst or in the middle can expect an MOE score of 0.71. This model placed 33 of the 86 company teams in the "0.86" node and the remaining 53 company teams in the "0.71" node.

Research Question 3. "All things taken equally, which potential indicators offer the best predictions of how survivable company teams will be?"

There are two reasonable ways to answer this question. First, build an overall model to represent the entire set of data. Second, build a model from everything except the execution phase to be used as a predictive tool immediately prior to a battle.

Both of these analyses are conducted in the same way as the analyses from Research Question 1. These analyses make use of regression trees and classification trees (with cross-validation to determine the sizes), as well as linear models. As with the regression trees, the classification trees will examine relationships between the independent variables and survivability. However, instead of using the MOE score as the dependent variable as the regression trees did, it will use a classification of survivability. This classification comes from dividing the company teams into two groups based on their MOE scores. As before, those company teams that received an MOE score greater than 0.65 are classified as "more survivable" and the remaining company teams are classified as "less survivable". Classification trees show the misclassification rate below the nodes. Instead, they. Consider the classification tree in Figure 17, for example. The root node shows an "M" in the middle and the fraction "19/68" below. This means that the majority of the points in the node were more survivable ("M"), but 19 of the 68 points in the node are misclassified by this label (not more survivable).

Figures 16, 17 and 18, respectively, show the size = 3 regression tree, classification tree, and linear model of the data (including execution phase). These were all made without Timeline and Actions on Contact. Each model was originally constructed using all indicators; however, Timeline and Actions on Contact did not appear significant in any of them. The models including Timeline and Actions on Contact were able to use only 43 lines of information because of missing data. Because eliminating them from consideration allowed for inclusion of more of the data set (68 lines), these two variables were dropped for this analysis. The linear model was built with argument "best = 3" in order to determine the three most influential indicators of survivability. This number was chosen arbitrarily with the intent to determine which three among the twenty independent variables was most significant. (For Research Question 1, the argument was "best =

1". For that question, we were only comparing five to seven independent variables and wanted to determine the one that was most influential. Here, we want to gain additional information.)
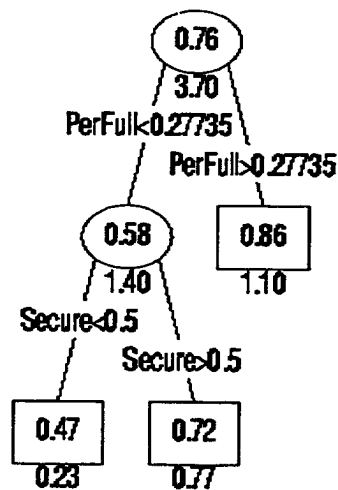
Figure 16. Regression tree (excluding Timeline and Actions on Contact).

Figure 17. Classification tree (excluding Timeline and Actions on Contact).

```
> summary(rq3lm)

Call: lm(formula = MOE3 ~ PerFull + TMB + Secure, data =
     RQ3R)
Residuals:
    Min       1Q        Median     3Q        Max
    -0.4147   -0.119    0.001357   0.09511   0.3921

Coefficients:
              Value     Std. Error    t value    Pr(>|t|)
(Intercept)   0.4875    0.0467        10.4322    0.0000
    PerFull   0.4295    0.0831        5.1675     0.0000
       TMB1   0.0362    0.0381        0.9482     0.3467
       TMB2   0.0477    0.0166        2.8653     0.0057
     Secure   0.1145    0.0451        2.5349     0.0137

Residual standard error: 0.1805 on 63 degrees of freedom
Multiple R-Squared: 0.446
F-statistic: 12.68 on 4 and 63 degrees of freedom, the
     p-value is 1.251e-007
```

Figure 18. Linear model (excluding Timeline and Actions on Contact).

The regression tree shows PerFull and Secure as most significant. This means the following:

- Company teams that maintain a full complement of their leadership for more than 27.735 percent of the battle (PerFull > 0.27735) can expect an MOE score of 0.86. Those who lose some of their leadership before the battle is 27.735 percent complete can expect an MOE score of 0.58.

- For company teams with PerFull < 0.27735, those that do not meet the standard on security operations can expect an MOE score of 0.47, while those who meet the standard can expect an MOE score of 0.72.

The classification tree shows PerDeg and Secure as most significant. This means the following:

- Company teams that fight more than 60.555 percent of the battle with their leadership degraded through combat losses (PerDeg > 0.60555) can expect to be "less survivable". All 31 company teams that had PerDeg < 0.60555 were "more survivable".

- Among those company teams with PerDeg > 0.60555, those that perform security operations to standard can expect to be more survivable and those that do not can expect to be less survivable. Twelve of sixteen company teams in this category were more survivable.

- Among those company teams with PerDeg > 0.60555 and Security = 0 (not performed to standard), those that fight less than 79.89 percent of the battle with a degraded level of leadership (PerDeg < 0.7989) can expect to be more survivable. All ten company teams that had PerDeg > 0.7989 were less survivable.

The linear model shows the presence of leadership (PerFull), security operations, and task organization (dominant system – tank, mechanized infantry, or balanced) as most significant. Note that PerFull, TMB2, and Secure all have p-values that are less than 0.05. This means that they all have significant relationships with the MOE score. The higher p-value for TMB1 is typical of categorical variables. Because the responses for TMB are "tank", "mechanized", or "balanced", the linear model will label them alphabetically and only include two of the responses in the model. TMB would not be significant if both of the p-values for the listed responses were greater than 0.05.

Overall, the effects of casualties among the leadership and performance of security operations are common to all three models. The models give a telling representation of company team survivability throughout the course of an operation. They basically say that company teams that keep their leadership alive and in the fight are more survivable than others. Further, they say that this is the primary discriminator between more and less survivable company teams. This is not terribly surprising, but it effectively points out the importance of leadership survival compared to all of the other indicators. The importance of security operations, however, is somewhat surprising. Although it is no surprise that security operations are important (see Potential Indicators), it is somewhat surprising that security operations are more indicative of company team survivability than many others. One possible explanation comes from Sergeant First Class Yamasta, a platoon O/C in the Armor Task Force Training Team (Cobras). When asked what he thought would be the

most significant indicator of a more survivable company team, he immediately answered: "I know as soon as I see how well they do their security operations." He went on to explain that more disciplined units maintain their security operations right from the beginning of the rotation. Because they are more disciplined as a unit, they will be more survivable in most of their battles during the rotation. Also, if company team morale begins to wane, it shows up first during the preparation phase when they drop their guard and stop performing their security operations to standard [Ref 8].

Figures 19, 20, and 21, respectively, show the size = 5 regression tree, classification tree, and linear model of the data excluding the execution phase. The models were made without regard to Timeline for the same reasons as the models that included the execution phase.
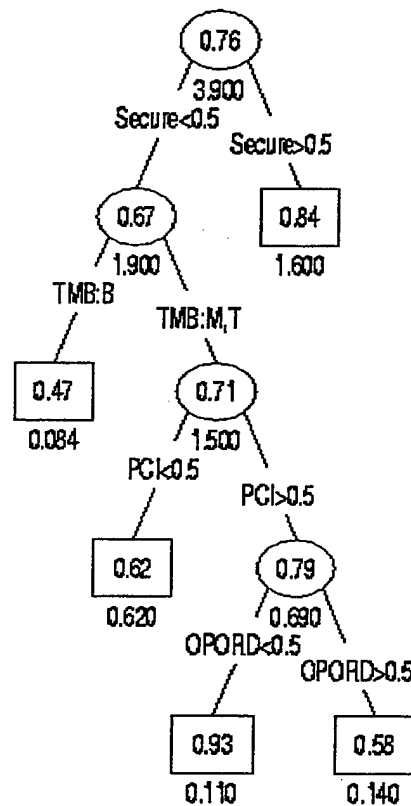
Figure 19. Regression tree (excluding execution phase).
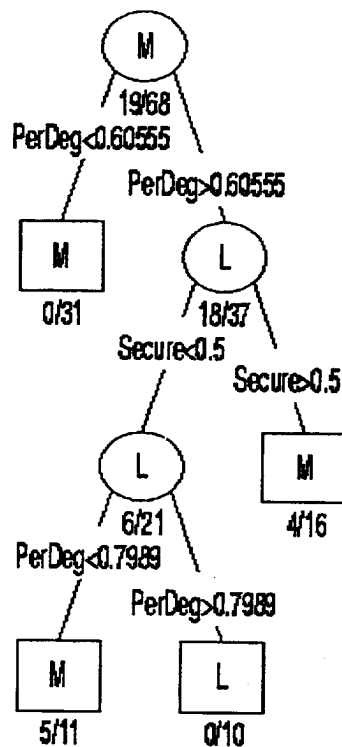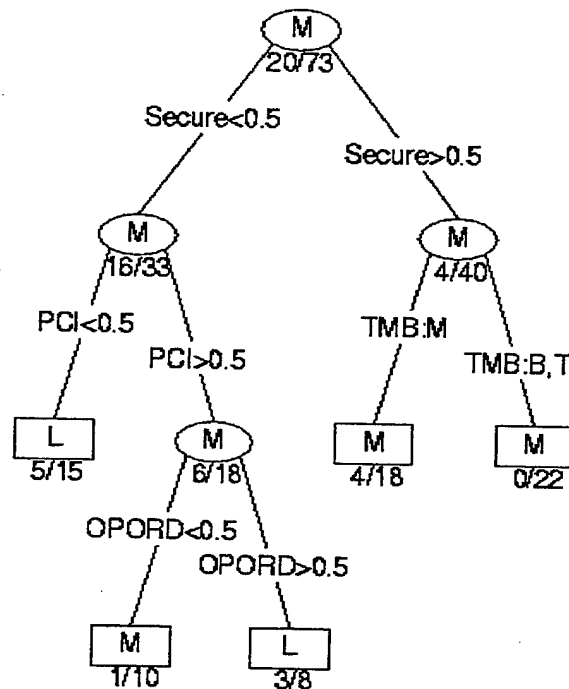
Figure 20. Classification tree (excluding execution phase).

```
> summary(rq3PPlm)

Call: lm(formula = MOE3 ~ OPORD + TMB + Secure, data =
    RQ3RPP)
Residuals:
    Min         1Q          Median      3Q          Max
    -0.5196     -0.112      0.01637     0.1386      0.3372

Coefficients:
                Value       Std. Error  t value     Pr(>|t|)
(Intercept)     0.7047      0.0447      15.7543     0.0000
      OPORD     -0.1097     0.0512      -2.1440     0.0356
       TMB1     0.0200      0.0396      0.5043      0.6156
       TMB2     0.0349      0.0182      1.9143      0.0598
     Secure     0.1868      0.0508      3.6799      0.0005

Residual standard error: 0.2095 on 68 degrees of freedom
Multiple R-Squared: 0.2368
F-statistic: 5.275 on 4 and 68 degrees of freedom, the
    p-value is 0.0009252
```

Figure 21. Linear model (excluding execution phase).

The trees show performance of security operations, task organization (dominant system), pre-combat inspections and operations orders as most significant. The regression tree, specifically, shows the following:

- Company teams that perform their security operations to standard (Secure = 1) can expect an MOE score of 0.84. This terminal node contained 40 of the 73 available company teams. Those who do not can expect an MOE score of 0.67.

- Among company teams with Secure = 0, balanced units can expect an MOE score of 0.47. This terminal node contained only five of the remaining 33 company teams. The tank heavy and mechanized company teams that do not perform security operations to standard can expect an MOE score of 0.71.

- Among company teams with Secure = 0 that are not balanced, those that do not perform their pre-combat inspections to standard (PCI = 0) can expect an MOE score of 0.62. This terminal node contained 13 of the remaining 28 company teams. Those with PCI = 1 can expect an MOE score of 0.79.

The linear model shows performance of security operations, task organization (dominant system) and operations order as most significant. Strangely, though, the coefficient for the OPORD variable is negative. This implies that doing worse on the OPORD indicates a larger MOE score for the company team. This will be discussed further in Chapter V. Also note that neither of the p-values for TMB are less than 0.05, although the lowest is close (0.0598).

Overall, performance of security operations and task organization figured prominently in all three models of the data taken prior to the execution phase of the operation. The importance of task organization is not surprising – we should not expect Bradley equipped company teams to be as survivable as those with tanks. This topic will be revisited in Research Question 6. The importance of security operations remains somewhat surprising, with the best available explanation coming from SFC Yamasta (stated earlier).

Research Question 4. "Which indicators, when examined individually, differ significantly between more and less survivable company teams?"

Answering this question required the use of three different tests, depending upon the nature of the data for the various indicators. Binomial tests were performed for indicators that were evaluated as "to standard" or "not to standard". Contingency tables were used to test categorical data. Wilcoxon Rank-Sum tests were used for the remaining indicators. The data for these indicators were all values between zero and one (inclusive), but not expected to follow a Normal distribution. The Wilcoxon Rank-Sum test was chosen because of its non-parametric nature. A description and example of each type of test follows. After that is a table summarizing the results of the test for each indicator. All tests treated company teams with an MOE score greater than 0.65 as "more survivable" and those with an MOE score less than 0.65 as "less survivable" (see Research Question 1).

The binomial test treats the data as if there were n Bernoulli trials related to the more survivable company teams and m Bernoulli trials related to the less survivable company teams. We test whether the true probability of success for more survivable company teams is the same as for less survivable company teams:

$$H_0: p_{\text{more survivable}} = p_{\text{less survivable}}$$

$$H_1: p_{\text{more survivable}} > p_{\text{less survivable}}$$

Note: H_1 varies for some indicators. Some will have $\neq$ or $<$ instead of $>$. H_1 for each indicator is shown in Table 5. This research continues to use an $\alpha = 0.05$ as the level of significance. In other words, we have one chance in twenty of rejecting H_0 when it is true. Letting $x =$ the number of "to standard" evaluations among the n more survivable company teams, and $y =$ the number of "to standard" evaluations among the m less survivable company teams, we reject H_0 whenever

$$\frac{\dfrac{x}{n} - \dfrac{y}{m}}{\sqrt{\dfrac{\left(\dfrac{x+y}{n+m}\right)\left(1 - \dfrac{x+y}{n+m}\right)(n+m)}{nm}}} \geq z_\alpha$$

This test was also used to determine the significance of effort (main vs. supporting), whether or not the unit was "pure" (as opposed to receiving attachments), and the mission type (offensive vs. defensive) [Ref. 9].

As an example, consider security operations. There were $n = 61$ more survivable company teams (MOE score > 0.65). Of these, $x = 41$ company teams performed security operations to standard. Of the $m = 22$ less survivable company teams, only $y = 4$ performed security operations to standard. For the equation above:

- $n = 61, m = 22, x = 41, y = 4$

- The test statistic is 3.957.

- z_α is 1.645.

- Because $3.957 \geq 1.645$, we reject H_0, with a p-value of 3.79E-05.

Table 5, below, shows the results of all Binomial tests that were conducted. Note the * in the right most column signifies those indicators that had a statistically significant (H_0 was rejected) relationship with survivability.

Indicators	n	m	x	y	Test Stat.	H_1	p-value
Type of Effort (main,supporting)	61	22	17	4	0.8960	$p_m < p_l$	0.815
Unit Purity (vs. attachments)	65	23	15	6	-0.2911	$p_m > p_l$	0.614
Mission Type (off., def.)	65	23	51	18	0.02010	$p_m \neq p_l$	0.984
OPORD (to standard, not t.s.)	64	23	32	12	-0.1788	$p_m > p_l$	0.571
Risk Assessment (t.s., n.t.s)	64	23	52	16	1.163	$p_m > p_l$	0.122
Timeline (≤ 0.33, > 0.33)	40	18	15	10	-1.284	$p_m > p_l$	0.901
Direct Fire Plan (t.s., n.t.s)	63	23	20	7	0.1159	$p_m > p_l$	0.454
Security Operations (t.s., n.t.s)	61	22	41	4	3.957	$p_m > p_l$	3.1E-05*
Combat Service Spt. (t.s., n.t.s)	64	23	47	12	1.872	$p_m > p_l$	0.0306*
Rehearsal Quality (t.s., n.t.s)	63	23	31	7	1.552	$p_m > p_l$	0.0604
Boresight (t.s., n.t.s)	64	23	53	15	1.752	$p_m > p_l$	0.0399*
Pre-Combat Inspect., (t.s., n.t.s)	64	23	40	11	1.226	$p_m > p_l$	0.110
Actions on Contact (t.s., n.t.s)	58	12	31	3	1.795	$p_m > p_l$	0.036*

Table 5. Binomial data tests. * = significance at $\alpha = 0.05$.

Contingency tables were used to test whether or not the categories for an indicator are independent of survivability. Consider, for example, task organization. Table 6 shows the contingency table for the company team's dominant system. There are separate columns for tank, mechanized, and balanced company teams. The rows identify the more and less survivable company teams. The top left entry, then, shows that there were 35 tank-heavy company teams that were more survivable. The far right column shows the sums for the rows. The bottom row shows the sums for the columns.

For contingency tables, we presume as a null hypothesis that the categories are independent. This means the proportion of more survivable company teams is the same for all types of company teams. Expected values were computed as follows:

$$Expected[Tank, More] \equiv \frac{(Total(More))(Total(Tank))}{Total}$$

Thus, the expected number of more survivable, tank-heavy company teams is (65 more survivable company teams) * (40 tank-heavy company teams) / (88 total company teams) = 29.55 company teams.

	Tank	Mechanized	Balanced	Total
More Survivable	35	24	6	65
E[More Survivable]	29.55	27.33	8.12	
Less Survivable	5	13	5	23
E[Less Survivable]	10.45	9.67	2.87	
Total	40	37	11	88

Table 6. Contingency table for task organization (dominant system).

Formally, for a contingency table test:

- H_0: dominant system and survivability are independent

- H_1: dominant system and survivability are dependent

- $\alpha = 0.05$

- The test statistic:

$$\sum \frac{(Value - E[Value])^2}{E[Value]}$$

- We reject H_1 if the test statistic $\geq \chi^2_{\alpha,((rows-1)(columns-1))}$

For the contingency table above, the test statistic is 7.531. Because there are two rows and three columns, the critical value is $\chi^2_{.05,2}$, which is 5.991. Since $7.531 \geq 5.991$, we reject H_0 with a p-value of 0.0232 and conclude that survivability varies for the different task organizations [Ref. 9].

Tables 7 and 8, respectively, show the contingency tables for size of company team and for rehearsal type. For both of these indicators H_0 is accepted. It appears that the probability of being more survivable does not differ for levels of either of these variables.

	Normal	Large	Small	Total
More Survivable	54	3	8	65
E[More Survivable]	52.44	3.69	8.86	
Less Survivable	17	2	4	23
E[Less Survivable]	18.56	1.31	3.14	
Total	71	5	12	88

Table 7. Contingency table for task organization (size of company team).

	Mounted	Dismounted	CheckBlock	None	Total
More Survivable	19	13	21	8	61
E[More Survivable]	18.6	12.65	20.83	8.93	
Less Survivable	6	4	7	4	21
E[Less Survivable]	6.4	4.35	7.17	3.07	
Total	25	17	28	12	82

Table 8. Contingency table for rehearsal type.

The Wilcoxon Rank-Sum test is a non-parametric test used to determine if the distribution of an indicator for the more survivable company teams is the same as the distribution for the less survivable company teams. To use the test, we first rank order the values for each indicator. For instance, the lowest value for PerDeg (percentage of the battle fought with a degraded level of leadership) is zero, so that data point is assigned a rank of 1. This continues through all available data points for that indicator. Once that is done, we sum the ranks from the more survivable company teams. The necessary calculations are as follows:

- $m =$ the number of more survivable company teams.

- $n =$ the number of less survivable company teams.

- $S =$ the sum of the ranks from the more survivable company teams.

- $E[S] = m(m + n + 1) / 2$.

- $Var[S] = mn(m + n + 1) / 12$.

- The test statistic is:

$$\frac{S - E[S]}{\sqrt{Var[S]}}$$

- $H_0: f_{\text{more survivable}}(x) = f_{\text{less survivable}}(x)$.

- $H_1: f_{\text{more survivable}}(x) = f_{\text{less survivable}}(x + \theta)$.

- $\alpha = 0.05$

- Reject H_0 if the test statistic $\leq -z_{\alpha}$..

For PerDeg: $m = 63$, $n = 23$, and $S = 2467$. Therefore, the test statistic is -2.668. Since the critical value is -1.645, we reject H_0 with a p-value of 0.00381 [Ref. 10]. Table 9, below, shows a summary of all Wilcoxon Rank-Sum tests for this research. An * indicates those indicators giving p-value ≤ 0.05.

Indicator	H_1	m	n	S	$E[S]$	$Var[S]$	test stat.	p-value
WARNORD	$f_m=f_l+\theta$	64	23	2919	2816	10795	0.991	0.161
Timeline	$f_m\neq f_l$	40	18	1238	1180	3540	0.975	0.330
OR Rate	$f_m=f_l+\theta$	65	23	2956	2892	11088	0.598	0.275
Volume of Fire	$f_m\neq f_l$	62	23	2722	2666	10220	0.554	0.580
Engage. Area	$f_m=f_l+\theta$	64	23	3022	2816	10795	1.983	0.0237*
PerDeg	$f_m=f_l-\theta$	63	23	2467	2740	10505	-2.668	0.0038*
PerLost	$f_m=f_l-\theta$	63	22	2545	2709	9933	-1.646	0.0499*
LostB4Cdr	$f_m=f_l+\theta$	63	22	2864	2709	9933	1.555	0.0599
DirFire Losses	$f_m\neq f_l$	65	23	3083	2892	11088	1.809	0.0704
Artillery Losses	$f_m\neq f_l$	65	23	2609	2892	11088	3.542	3.97E-4*
Maint. Losses	$f_m\neq f_l$	65	23	3054	2892	11088	0.684	0.494
Mine Losses	$f_m\neq f_l$	65	23	2973	2892	11088	0.195	0.846

Table 9. Wicoxon Rank-Sum tests. * = significance at $\alpha = 0.05$.

In answer to the research question, then, the following indicators, when examined individually, differ significantly between more and less survivable company teams:

- Performance of Security Operations.
- Performance of Combat Service Support Operations.
- Performance of Boresight Operations.
- Performance of Actions on Contact.
- Proportion of the battle fought with a Degraded Level of Leadership.
- Proportion of the battle fought with Leadership Lost.
- Proportion of Losses to Indirect Fire.
- Effects of Enemy Engagement Areas.
- Task Organization (Dominant System).

The above indicators were shown to have significant relationships with survivability by one of the three tests described above.

Research Question 5. "Does task organization affect company team survivability?"

There are three ways to examine this question. Does the company team's principal system have any affect? Does the size of the company team matter? Do attached assets affect survivability? Each of these questions was answered in Research Question 4. A brief description follows.

The company team's principal system does affect company team survivability. This was shown with a contingency table (Table 6). Tank heavy company teams are more survivable than mechanized and balanced company teams. This is entirely reasonable; tanks are made to be the most survivable systems on the battlefield. Company teams with a higher proportion of Bradleys are more susceptible to losses from lower caliber weapons.

Size of the company team is not an indicator of survivability. As shown in Table 7 (Contingency table for size of company team), we cannot reject a null hypothesis that a company team's size and survivability are independent.

Attached assets do not affect a company team's survivability. The proportion of more survivable company teams that were pure was 0.23. The proportion of less survivable company teams that were pure was 0.26. That is not a significant difference for this sample size. Therefore, we cannot reject the null hypothesis that the probability of a more survivable company team being pure is the same as the probability of a less survivable company team being pure.

Research Question 6. "Does the type of mission cause different indicators to become more indicative of the level of company team survivability?"

To answer this question, we begin by splitting the data into two sets, one set for offensive operations and another set for defensive operations. We then conduct analysis as we did for Research Question 3 to determine which independent variables are most

indicative of survivability. Figures 22 and 23, respectively, show the regression trees for the offensive and defensive operations.
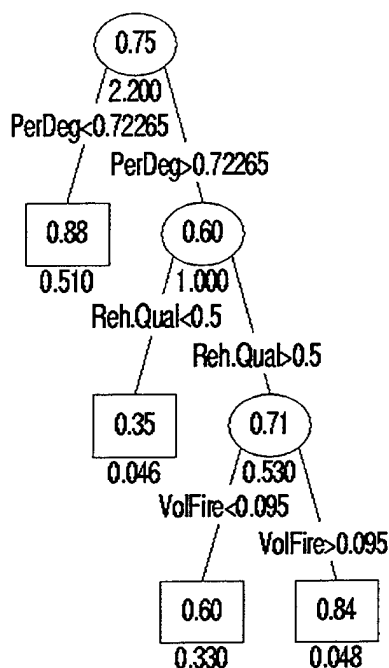
Figure 22. Regression tree for offensive operations.
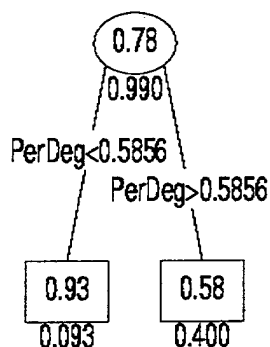
Figure 23. Regression tree for defensive operations.

Both trees show that the effect of casualties among the leadership as the most significant indicator of survivability. This was previously shown to be the most significant indicator for all operations (see Research Question 3, Figure 16). The regression tree for the defensive operations is much smaller because it had less data – only 25 percent of the

battles in the data set were defenses. One key difference shown here, though, is the presence of rehearsal quality performance as an indicator. Among those company teams that fight offensive battles with their leadership degraded more than 72.265 percent of time, those that conduct "to standard" rehearsals can expect an MOE score of 0.71. Among the same company teams, those that do not conduct their rehearsals to standard can expect an MOE score of 0.35.

Because the performance of rehearsals is significant in offensive operations but not in all operations, we can say that this indicator is more relevant for offensive operations than defensive operations. This seems entirely logical. Rehearsals typically focus on the scheme of maneuver for an operation. For offensive operations, the movement formations and techniques that the platoons must execute often require significant rehearsal. Defensive operations, on the other hand, are usually not as reliant on successful maneuver.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This research seeks to draw conclusions in three ways. First, it must answer the questions that were asked in Chapter I: "Which company team was the most survivable within its task force?" And furthermore "What did that company team do to become the most survivable?" In other words, what did the data tell us? Second, it should point out surprises that cause us to wonder about what the data did *not* tell us. Finally, it will examine the conclusions themselves to see if they are valid and relevant.

This research answers the "which company team" question by developing an MOE based upon average survival time of systems within a company team relative to other company teams in the same task force. Although this is by no means a perfect way to assess survivability, it offers a quantitative method for comparison. A company team that scored 0.95 certainly did a better of job of keeping its systems alive than a company team from the same task force that scored 0.52. Despite any criticisms of the MOE, it accomplishs its purpose – it answers the question in such a way that we can go about the business of answering the more telling second question.

The "what did that company team do" question was answered in detail in Chapter IV. To summarize, there are three major and five minor differences between more and less survivable company teams. The more survivable company teams are usually tank pure or have been task organized to have more tanks than Bradleys. They keep their leadership alive longer, and they perform security operations to standard. And, generally, the more survivable company teams conduct boresight, actions on contact and combat service support operations to standard. They suffer a lower proportion of their losses to indirect fire and avoid the effects of enemy engagement areas (as defined in Chapter IV, Section A).

The above paragraphs relate what the data tell us. There are, however, some surprises. Certain indicators that are taught repeatedly in service schools which develop the Army's combat leaders and are further emphasized by BLUEFOR commanders and the National Training Center's Observer/Controllers do not show up as having significant relationships with survivability. We would expect that the more survivable company

teams would produce operations orders that were to standard more often than less survivable company teams do. We would expect the same about the quality of rehearsals. Also, we would expect those company teams that better manage their timeline and allow their subordinate leaders more preparation time would be more survivable. The data do not allow us to make such conclusions. Exactly half (32 of 64) of the more survivable company teams prepared their OPORDs to standard, while a similar proportion (12 of 23) of the less survivable company teams did so. Why this occurs is open to much speculation, the bulk of which centers on the subjective nature of the evaluations. This is the most complex task that the O/Cs evaluate subjectively; therefore, it is naturally the most variable among evaluators and O/C teams. As for rehearsal quality, a higher proportion (23 of 63) of more survivable company teams performed this task to standard than did the less survivable company teams (7 of 23). Because of the relatively small sample size, however, the difference is not statistically significant and we cannot draw any firm conclusion about the relationship between rehearsal quality and survivability (except for during offensive operations, as noted in Chapter IV in the analysis for Research Question 6). Timeline management, however, might be the greatest mystery. Among the more survivable company teams, the average proportion of time used was 39 percent and only 38 percent of those units met the "one-third / two-thirds" rule. Compare that to the less survivable company teams, who used an average of 34 percent of the available time and had 56 percent of the units meet the rule. One viable explanation is in Chapter IV as part of the answer to Research Question 1. In any event, the data do not allow us to draw any conclusions about the relationship between timeline utilization and survivability.

We must consider whether these and other surprises imply that Army service schools, unit commanders, and O/Cs at the NTC have placed their emphasis in the wrong areas. Should they shift their priorities to focus on security operations and keeping unit leadership in the fight? Although that seems far-fetched and will be answered specifically in the recommendations that follow, we should reexamine the quality of the data from which the conclusions are drawn as well as their applications to survivability.

Remember that the conclusions stated above are based upon manually gathered and largely subjective data. The manually collected data are inferior to what an automated

system could provide. Unfortunately, the current automated data collection and database system at the NTC has a low "pairing" rate that causes the collected data to be incomplete. In other words, most of the events that occur in the field do not get properly or completely logged into the database. Thus, any attempts at analysis of the automated data could be biased by a variety of automation factors, such as signal strength, etc. Also, the subjective nature of many of the evaluations cause disparity in data collection from the various O/Cs and O/C teams – despite their efforts to standardize among themselves. The teams evaluate different tasks and use different grading scales. The conclusions from this research could not include tasks that were not evaluated by all three O/C teams and were subject to scale modifications to make them compatible.

As far as the conclusions' applications to survivability, we must take into account the formulation of the MOE. One problem with the MOE is that it will favor units which, by chance or design, are simply away from their task forces' most significant action. Another methodology could focus on lethality instead of (or along with) survivability. Given the NTC's current data collection assets, lethality is extremely difficult to judge. The automated system does not give an accurate assessment of who-killed-whom. Manual collection of these data, while not impossible, would significantly impact the other duties of the O/Cs as well as the OPFOR.

Something else to consider when we examine survivability at the National Training Center is that the battles there are really just very high resolution models of combat. We would hope that real battles do not result in the high casualty levels that NTC battles do. Soldiers do not really die in battles fought with MILES. Through the course of their four or five MILES battles at the NTC, along with countless drills and battles at other training locations throughout their respective careers, soldiers become desensitized to being "hit" by MILES. It would be reasonable to assume that soldiers would behave differently if there were real bullets coming at them. An analysis of real battles would logically use a more definite MOE (like proportion of systems that survived the battle) and might very well bring different answers to the same questions. That point, however, is moot. The NTC is the most realistic place in the United States Army to analyze mounted operations. We cannot evaluate combat the way we evaluate training events.

That said, the conclusions of this research are valid. Their applicability, however, must consider the shortcomings noted above. The recommendations that follow, then, attempt to make the most of these conclusions while blending in the realities of experience.

B. RECOMMENDATIONS

The training community that should take note of these findings includes both units in the field as well as the relevant service schools. These schools include the Infantry and Armor Officer Advanced Courses, the Infantry and Armor Officer Basic Courses, and the Advanced Non-Commissioned Officer Courses for 11Ms and 19Ks. (11M is the Military Occupational Specialty designation for mechanized infantrymen and 19K is the MOS designation for Abrams tank crewmen.) These courses teach the company commanders, platoon leaders and platoon sergeants, respectively, a variety of tasks that prepare them to perform their duties.

Task forces should consider survivability when they assign task organizations for an operation. They must consider that their tank heavy company teams are more survivable than their mechanized company teams. This holds a variety of tactical implications for the planning staffs and is something that should be discussed during the staffs' wargaming of particular courses of action.

Making concerted efforts to keep leadership alive in the battle is contrary to the lead-from-the-front attitude that many leaders believe in and teach to their subordinate leaders. But the claim remains: company teams that keep their leadership alive longer are more survivable. We must keep in mind that keeping leadership alive does not mean sacrificing subordinates. It means exercising caution when in contact. It means not blundering into engagement areas. It means taking a position from which to see the battlefield and then making life and death decisions for the leader himself, his subordinates, and the enemy. Living leaders can lead their company teams to their objectives. Dead leaders cannot lead anyone.

Units and schools should add focus to security operations. Service schools often overlook security operations in favor of other tasks. While they are all important, we cannot deny the significant relationship between security operations and survivability.

70

Small unit leaders must be proficient in all tasks that support security operations. Units need to stress these as part of their Standard Operating Procedures (SOP). A well-disciplined company team conducts their security operations as a matter of professionalism. Because security operations must be maintained throughout a training event, those units that are able to maintain a secure posture and properly conduct security tasks are often professional enough to do many other things well.

The NTC's Operations Group is working toward fixing its automated data collection problems. It needs to continue to do so. With each improvement in the pairing rate, the NTC should sample the database to see how well it compares to the current manual data collection. Comparisons for this research (made from the November 1997 rotation) showed that the manual data is vastly superior to the automated data. The quality gap should improve with each increase in the pairing rate. Sampling could also point out problems other than the pairing rate that will need to be addressed before the database is to be of any use.

The NTC should also adopt a standardized method of making and collecting subjective assessments. The Cobra Team experimented with one such system in the February 1998 rotation. Captain Dana Goulette's thesis, "Training Assessment and Modeling Subjective Data Encapsulation for the National Training Center," provides another system that would accomplish this [Ref. 4]. Once the NTC adopts a standardized system, data can be entered into the automated system and the two sources of data could then be analyzed for further research. Currently, data analysis conducted at the NTC must begin with data collection to fit each particular research project. If each team collects the same data measured on the same scale, future research can collect data "off the shelf". This would allow for significantly larger data sets from which to draw more confident conclusions.

APPENDIX A. SAMPLE DATA

Below are the data from two of the task force battles that were used for this research. For ease of reading, they are broken into four sections. The first section includes the administrative data. The second, third, and fourth sections show the planning, preparation and execution phases, respectively.

Rotation	Train. Day	Task Force	Comp. Team	MOE Score	Effort	TMB	NLS	PX	Mission
98-03	1	3-8Cav	C Tank	0.38	Main	Tank	Large	Xattach	Offense
98-03	1	3-8Cav	D Tank	1.00	Spt	Bal.	Small	Xattach	Offense
98-03	1	3-8Cav	A Mech	0.92	Spt	Mech	Normal	Xattach	Offense
98-03	1	3-8Cav	D Mech	0.80	Spt	Mech	Normal	Xattach	Offense
98-04	5	3-15Inf	B Tank	0.87	Main	Tank	Normal	Pure	Offense
98-04	5	3-15Inf	C Tank	0.50	Spt	Tank	Normal	Xattach	Offense
98-04	5	3-15Inf	A Mech	1.00	Spt	Mech	Normal	Xattach	Offense
98-04	5	3-15Inf	D Mech	0.54	Spt	Mech	Normal	Pure	Offense

WARNORD & Graphics	OPORD	Risk Assessment	Timeline (percentage)	Timeline (boolean)	Direct Fire Plan
1	0	1	0.33	1	0
1	1	1	0.59	0	1
1	1	1	0.38	0	1
1	0	1	0.45	0	0
1	1	1	0.62	0	0
1	1	1	0.25	1	0
0	0	1	0.20	1	0
1	1	1	0.28	1	0

Secure	Combat Serv. Spt	Rehearsal Quality	Rehearsal Type	Boresight	Pre-Combat Inspection	Oper. Ready Rate
0	0	1	Mounted	1	0	0.67
1	1	1	Dismt.	1	0	1.00
0	0	0	Check-block	1	0	1.00
1	1	0	Check-block	1	0	0.79
1	1	1	Mounted	1	1	0.86
0	0	0	Check-block	1	0	0.57
1	1	0	None	0	0	0.79
0	1	1	Mounted	1	1	0.86

AOCs	Vol. Fire	Eng. Area	Per. Full	Per. Deg.	Per. Lost	Lost B4Cdr	Loss to DF	Loss to Arty	Loss to Maint	Loss to Mine
1	0.09	0.04	0.18	0.82	0.69	0.08	0.92	0.00	0.08	0.00
1	0.21	1.00	1.00	0.00	0.00	1.00	0.00	0.50	0.50	0.00
1	0.11	0.08	0.83	0.17	0.15	0.60	0.20	0.30	0.10	0.40
1	0.03	0.08	0.82	0.18	0.10	0.83	0.54	0.00	0.45	0.00
0	0.17	0.14	0.19	0.81	0.00	1.00	0.82	0.09	0.09	0.00
1	0.17	0.12	0.18	0.82	0.70	0.75	1.00	0.00	0.00	0.00
1	0.13	0.03	0.36	0.64	0.62	0.81	0.73	0.18	0.00	0.00
NA	0.00	0.17	0.25	0.75	0.72	0.92	1.00	0.00	0.00	0.00

TF:	1-9 CAV					LD/Def Time:	9:30				
TD:	13					Chg Msn Time:	11:45				
Mission:	LF DEF										

11 Team	CO/TM: A(T)		12 Team	CO/TM: B(T)		13 Team	CO/TM: B(M)		14 Team	CO/TM: C(M)	
BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.
A66	10:00	30	B66	11:25	115	B66		135	C66	10:07	37
A65	11:15	105	B65	10:05	35	B65		135	C65	9:30	0
A11		135	B12	9:52	22	B11		135	C21	10:02	32
A12		135	B13	11:30	120	B12		135	C22	10:08	38
A14		135	B14	11:20	110	B14	11:25	115	C23	9:54	24
A22	11:22	112	B22	10:02	32	B31	11:23	113	C31	10:15	45
A23	11:25	115	B23	9:58	28	B32	11:17	107	C33	11:30	120
A24	11:20	110	B24	11:20	110	B33	11:21	111	C34	9:30	0
C12	9:45	15			0	B34		135	A31	10:10	40
C13	11:30	120			0	B21	11:31	121	A32	9:50	20
C14	11:35	125			0	B22	9:50	20	A33	11:30	120
		0			0			0			0
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		0			0			0			0
Total Surv Time:		1137	Total Surv Time:		572	Total Surv Time:		1262	Total Surv Time:		476
Average Surv Time:		103.36	Average Surv Time:		71.50	Average Surv Time:		114.73	Average Surv Time:		43.27

Most survivable company team for this battle is :	B(M)

Notes: Only record tanks and Bradleys
Only record systems that started the battle
Fill in all shaded areas
Record time in this format: 12:34

TF:					LD/Def Time:						
TD:					Chg Msn Time:						
Mission:												

11 Team	CO/TM:		12 Team	CO/TM:		13 Team	CO/TM:		14 Team	CO/TM:	
BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.	BMPR#	TOD	Surv. Tm.
		0			0			0			0
		0			0			0			0
		0			0			0			0
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		0			0			0			0
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		0			0			0			0
Total Surv Time:		0	Total Surv Time:		0	Total Surv Time:		0	Total Surv Time:		0
Average Surv Time:		0.00	Average Surv Time:		0.00	Average Surv Time:		0.00	Average Surv Time:		0.00

Most survivable company team for this battle is :   0

Notes: Only record tanks and Bradleys

Only record systems that started the battle

Fill in all shaded areas

Record time in this format: 12:34

GLOSSARY

AAR – After Action Review. An event that gives units an opportunity to reflect on what happened during an operation and identify those tasks which the unit must sustain proficiency and which the unit must improve to reach the standard.

AO – Area of Operations.

BDA – Battle Damage Assessment. A list of losses that occurred in a battle. It may include friendly and / or enemy losses, times of losses, causes of losses, etc.

BLUEFOR – The unit that is training for combat. BLUEFOR is short for "Blue Force", which is a nickname for the "good guys" that is derived from the fact that military maps will show the drawers units and graphics in blue, while showing his or her enemy's in red.

CAV – Cavalry. This term refers to a divisional cavalry squadron, regimental cavalry, and armor and mechanized infantry battalions of the 1st Cavalry Division.

COM – Change of Mission. This occurs at the end of a training battle. Its purpose is to instruct the training unit to discontinue its current operation and begin preparation of the next mission.

CONUS – The Continental United States.

CO/TM – Company / Team. This is a force, commanded by a captain, with a approximately 10 to 20 fighting systems (such as tanks, IFVs, infantry squads, etc.). A company is "pure", meaning it has its assigned equipment (14 tanks for a tank company, 14 IFVs and 6 squads of infantry for a mechanized company), no more and no less. A team is a company that has been task organized for a particular mission or operation. This is usually accomplished by attaching or detaching platoons from one company to another.

IFV – Infantry Fighting Vehicle. Similar to a tank in that they are armored and have some heavy weapons such as an anti-tank missile and/or machine guns. They carry infantry into battle and provide protection for them once dismounted. The United States Army uses the M2 Bradley as its IFV, similarly to other nations using the BMP (most for Soviet Block nations, most of the Arab nations), Scorpion and Scimitar (United Kingdom), etc., and the United States Marine Corps using the LAV25.

MECH – Mechanized Infantry.

MILES – Multiple Integrated Laser Engagement System. See Chapter II.

MTC – A movement to contact, which is an offensive operation that is conducted when an enemy's location and activity is unknown and / or uncontrolled. An MTC is conducted to gain and maintain contact with the enemy.

NTC – The National Training Center at Fort Irwin, California. The NTC performs the mission of preparing battalion task forces and brigade staffs for combat. See Chapter II.

O/C – Observer / Controller. These are soldiers from the NTC's Operations Group that work with the training unit to provide feedback, manage the operations, and ensure safety during the units' rotations.

OPORD – Operations Order. This is the five-paragraph plan that commanders issue to their subordinates so that they can execute a mission. It includes a description of the situation, the mission statement, how the plan will be executed, instructions concerning service support, and instructions concerning command and signal. It might also include annexes concerning anything special or peculiar to the operation.

OPFOR – Generic term for the "opposing force", or "bad guys", in force-on-force training. An OPFOR will replicate enemy forces so that units can conduct realistic training. See Chapter II.

PCI – Pre-Combat Inspection. See Chapter IV, Section A.

SAWE – Simulated Area Weapons Effects. See Chapter II.

TAF – Tactical Analysis Facility. Each task force O/C team at the NTC has a TAF from which to observe certain aspect of the battle. It monitors all audio signals from the training unit. It also has video monitors that show digital icons representing all systems on the battlefield. The TAF serves as the focal point for data collection and preparation of the task force AARs.

THP – Take Home Package. The collection of all AAR slides, overhead pictures from battles, statistics on battle damage assessment and subjectively evaluated areas, etc., from the entire rotation. The O/C teams provide a THP for every battle task force that trains at the NTC.

TOW – Tube launched, Optically sighted, Wire guided missile. This is the Army's premier anti-tank missile. It is launched from several platforms, including the Bradley Infantry and Cavalry Fighting Vehicles, dismounted tripods, Improved TOW Vehicles, and High-Mobility Multipurpose Wheeled Vehicles (HMMWVs).

WARNORD – Warning Order. See Chapter IV, Section A.

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